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INVENTORY OF RESEARCH IN WATER POLLUTION AND OTHER RELATED FIELDS, COLUMBIA BASIN AND PACIFIC COAST STATES

Lyman J. Nielson

Pacific Northwest Water Laboratory
Corvallis, Oregon

November 1966

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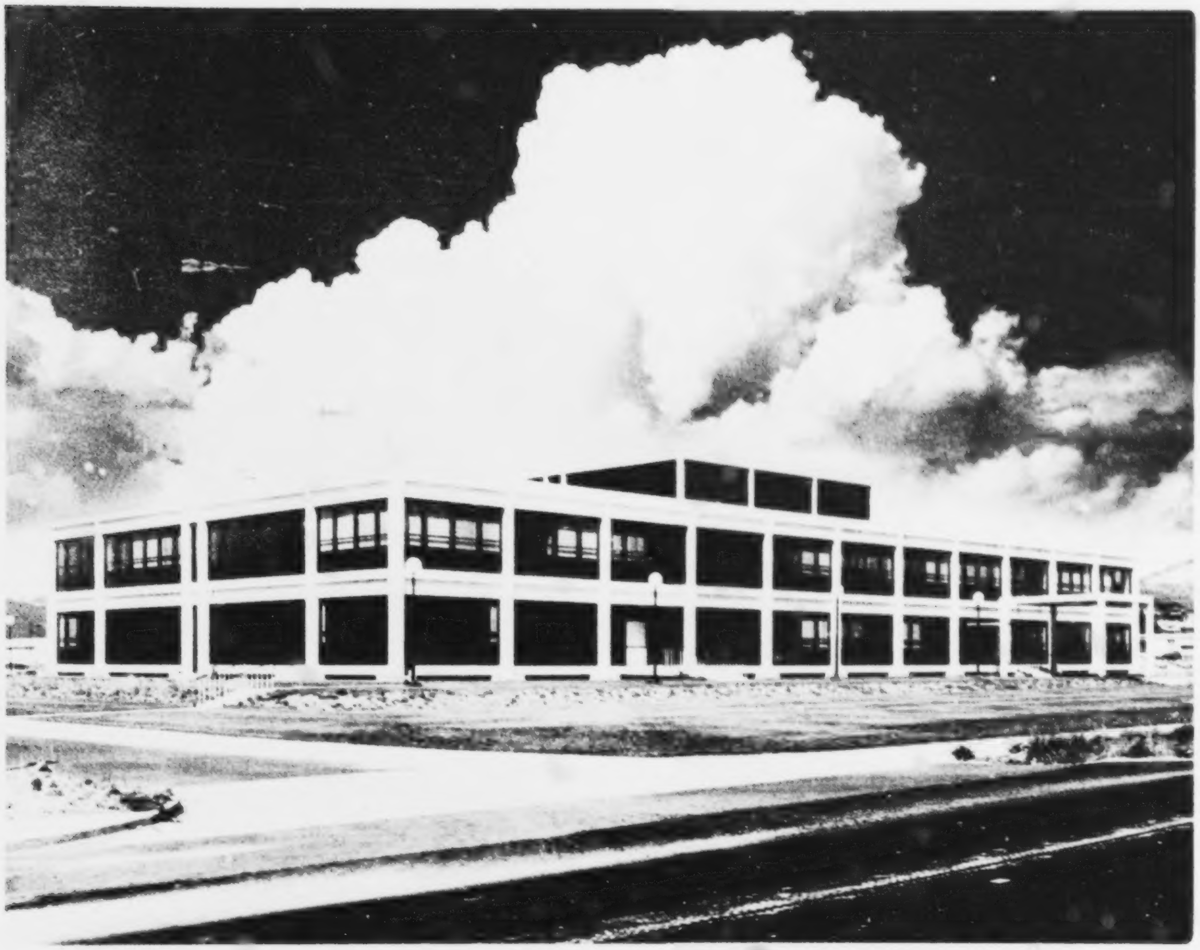

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Pacific Northwest Water Laboratory
Corvallis, Oregon

November 1966

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Compiled by
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FOREWORD

In 1957, Mr. Edward F. Eldridge, Technical Consultant to the Federal Government's water pollution control activities headquartered in Portland, Oregon, introduced the first Inventory of Research in Water Pollution and Related Fields -- Columbia Basin and Pacific Coast States. Since that time periodically updated inventories have served as useful tools to scientists engaged in water pollution control activities. The current issue derives from the earlier inventories. It has been expanded to provide information on the distribution of resources and efforts among the various categories of water pollution research, and the range of participation by professional discipline. It is hoped that this document will stimulate closer working relationships among the Region's scientists and will improve coordination of their efforts.

a. F. Bartsch
Director of Research

INTRODUCTION

This is the seventh inventory of water pollution research for the Columbia River Basin and Pacific Coast States. In addition to the customary abstract of each research project, this issue provides information relating to distribution of efforts in various areas of water pollution research. Each researcher submitting data for the inventory was asked to indicate the pertinent research area or areas of his project. The data submitted are given in three tables.

Table I, Allocation of Financial Resources, provides information on the relative distribution of research funds. Inasmuch as researchers reporting did not, in many cases, indicate the major emphasis of research but simply checked several categories, this table shows a total of 517 project activities, whereas only 215 projects were reported. To determine the over-all stress of research, whenever more than one area of research was indicated, the funds for the project were divided equally among all categories checked.

The total financial resources shown in Table I are extrapolated to indicate the probable totals for all projects reporting. This was necessary because a number of researchers failed to provide financial data.

Table II is a summary of the source of research funds. Funds shown under states and universities include not only research financed by various state agencies, but also research initiated and budgeted by the universities.

Table III provides data on Personnel Resources. Manpower information for 182 projects indicates that 671 persons are employed in water pollution research in the states of Alaska, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming, and the Province of British Columbia. This figure is undoubtedly high because the same personnel may be used on more than one project. For this reason the 422.3 man years per year of research effort are considered a better measure of manpower allocated to this research. It should be noted that 33 projects, or over 15 percent of the research summaries submitted, did not contain data on personnel resources used. Had all projects reported manpower, approximately 500 man-years annually would be indicated.

This table reveals a wide diversity of disciplines interested in water pollution control. Sixteen professional skills were listed, including the "doctor" and "lawyer", if not the "Indian Chief", in addition to special consultants and technicians. This spread of interest among many disciplines may be indicative of increasing awareness to the problem of water pollution as it touches virtually every aspect of human behavior.

The research summaries are grouped alphabetically by states. Each project has been numbered for indexing. In the research index each project is listed under all pertinent areas. For example, project number one is related to watershed protection, fish and wildlife, and effects of pollution, and is therefore indexed under all three headings.

The listing of each research project contains the following basic information as submitted:

(1) Title of project,

(2) Name of institution doing research,

(3) A summary or abstract of project including objectives,

(4) Date project was started,

(5) Estimated duration of project,

(6) Name of principal investigator,

(7) Number and disciplines of personnel on project,

(8) Unusual or extraordinary equipment, and

(9) Brief bibliography of pertinent publications.

TABLE I

CATEGORY OF RESEARCH	NUMBER OF PROJECTS INDICATING ACTIVITY	AVERAGE PRO-RATA FINANCING (1)	TOTAL FINANCIAL RESOURCES (2)
Advanced Waste Treatment	17	$21,253	$361,301
Aqueous Solutions	10	3,577	35,770
Characterization	58	11,086	642,988
Disposal of Waste Effluents	39	15,719	613,041
Economics of Development	10	2,516	25,160
Effects of Development	22	12,743	280,346
Effects of Pollution	78	20,663	1,611,714
Estuarine Oceanography	26	17,759	461,734
Fish and Wildlife	44	15,146	666,424
Improved Treatment	10	7,191	71,910
Interaction of Wastes	6	4,441	26,646
Miscellaneous	53	19,126	1,013,678
Quality Characteristics	57	10,322	588,354
Role of Water in Growth	1	--	--
Surface Interaction	12	16,900	202,809
Treatment of Water	10	22,190	221,900
Use of Water of Impaired Quality	18	10,410	187,380
Water Supply	24	21,733	521,592
Watershed Protection	22	10,077	221,694
TOTAL	517	14,999	7,754,441

(1) Total financial resources reported for a project were pro-rated to each category of research. Thus a project involving five different categories of research and having a $10,000 budget is listed as $2,000 for each of the categories indicated.

(2) This total is extrapolated to include financial resources for projects where funding was not reported.

TABLE 11

FINANCIAL RESOURCES ALLOCATED FOR RESEARCH*

SOURCE OF FUNDS	CURRENT YEAR	PERCENT OF TOTAL
Federal	$3,373,790	62.27
States & Universities	1,504,483	27.77
Municipal	12,905	0.24
Industrial	292,043	5.39
Not Indicated	234,437	4.33
TOTAL	$5,417,658	100.00

*In 26.5 percent of the research summaries submitted, financial resource information was not given.

TABLE III

PERSONNEL RESOURCES

DISCIPLINE	NUMBER REPORTED	MAN YEARS/YEAR
Engineers	151	84.0
Chemists	85	48.5
Biologists	173	122.5
Microbiologists	52	34.3
Oceanographers	31	27.8
Geologists	14	7.5
Soil Scientists	14	7.3
Mathematicians	9	5.0
Economists	4	2.5
Hydrologists	6	5.5
Foresters	4	3.1
Biochemists	1	0.5
Meteorologists	1	1.0
Doctors of Medicine	1	1.0
Lawyers	1	0.1
Sanitarians	1	0.5
Technicians	113	69.7
Consultants	10	1.5
TOTAL	671	422.3

33 projects not reporting.

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ALASKA

1 MONITORING THE EFFECTS OF LAND USE ON SALMON PRODUCTION: Alaska Department of Fish & Game, cooperating with U. S. Bureau of Commercial Fisheries, U. S. Forest Service, Region 10, Juneau.

Object: To detect changes in the stream environment that may result from land use and evaluate such changes (to a large extent in a quantitative manner) so remedial action may be taken or the pattern of land use management practices may be changed to obtain satisfactory results.

Characteristics Monitored: (1) Composition of streambed spawning areas. (2) Stream channel configuration and amount and kind of debris in the stream. (3) Streamflow and water temperature. (4) Classification of soil types in the watershed. (5) Sources of sediment. (6) Production of salmon fry and survival. (7) Assessment of adult salmon escapement. Primary effort to date has been in conjunction with logging and road building. The maximum effort anticipated is the extension of monitoring activities to ten different drainages with varying physical characteristics. The studies have been a cooperative venture between the U. S. Forest Service and the Alaska Department of Fish and Game with each agency responsible for part of the work; recently the Alaska Department of Fish and Game is receiving support from the Federal Government under the Commercial Fisheries Research and Development Act.

Project started: Spring 1963 (duration - five or more years).
Personnel: 1 biologist, 1 fisheries technician, 1 temporary employee.
Principal Investigator: Theodore C. Hoffman.

Publications: Hoffman, Theodore C., William L. Sheridan and Frank J. Ossiander. 1965. Effects of causeway construction at Starrigavan Creek, Southeastern Alaska. Alaska Department of Fish and Game, Information Leaflet No. 71, 32 p. (Processed).

Hoffman, Theodore C. and William L. Sheridan. 1965. A technique for evaluating effects of land use on salmon streams. Alaska Science Conference Proceedings for 1965. (In process).

2 PESTICIDES INVESTIGATIONS: U. S. Bureau of Commercial Fisheries, Juneau.

Project consists of two phases:

(1) Monitoring of environment of fishes, especially for DDT.

(2) Cooperative program of research (U. S. Forest Service and U. S. Bureau of Commercial Fisheries) to develop a biological control of blackheaded budworm. The acceptable control organism must be harmless to fish and shellfish and effective enough to make chemical pest control unnecessary.

A third phase has been completed: Effect of 1/4 pound per acre DDT application on stream ecology.

Project started: 1960.
Personnel: 2 biologists.
Principal Investigator: Howard S. Sears.

Special Equipment: Continuous running supply of freshwater and sea-water; complete facilities for maintaining fish and shell fish alive. Spectrophotometer, Fluorometer, Gas Chromatograph.

Publications: Reed, Roger J. Effects of DDT on the ecology of salmon streams in Southeastern Alaska. (In press).

3 KINETICS OF VITAMIN LIMITED ACTIVITY: Institute of Water Resources, University of Alaska, College.

The objective of this project is to relate the concentration of one class of required nutrients to microorganism growth velocity to assess the significance of naturally occurring concentrations of vitamins. Thiamine and the Thiamine requiring yeast Cryptococcus albidus are being used for the required kinetic measurements.

Project started: December 1, 1965.
Personnel: 1 microbiologist, 1 biochemist.
Principal Investigator: D. K. Button.

Special Equipment: Continuous culture system.

4 THE DISTRIBUTION AND SUCCESSION OF AQUATIC PLANT COMMUNITIES IN RELATION TO PHYSICAL-CHEMICAL CHARACTERISTICS OF VARIOUS LAKES AND PONDS OF THE TANANA VALLEY, CENTRAL ALASKA: University of Alaska, College.

This study is an attempt to rectify the dearth of information concerning the distribution, community associations and successional sequences of aquatic vascular plants in lentic habitats of Central Alaska, so as to allow generalized regional conclusions regarding the effects of physical-chemical characteristics of water on the nature of aquatic vegetation, and the latter on water characteristics. Through an analysis of aquatic begetation samples (for species composition, abundance, frequency, cover and/or species dry weights) at each of various stations established at different water depths, bottom types, and exposures to wave action in the limnetic zone and immediate land margin of various different-sized lakes and ponds of the Tanana Valley, interior Alaska, quantitative descriptions of aquatic tracheophyte communities are being made. An attempt is being made to assess relative ecologic positions or successional trends of aquatic plant associations along lake margins and to correlate this vegetational information with data to be obtained from an analysis of water characteristics (including temperature at various depths, pH, dissolved oxygen content, light penetration, salinity, total hardness) at the same stations sampled at regular 2-3 week intervals throughout the summer season. The study should result in a better understanding of the interrelations of water characteristics and aquatic vascular vegetation including the possible role of aquatic vascular plant communities as useful indicators of physical-chemical characteristics of lakes and ponds in interior Alaska.

Project Started: January 1966 (duration - to May 1967).
Personnel: 2 biologists.
Principal Investigator: Dr. Vernon L. Harms.

5 INHERENT AND MAXIMUM MICROBIAL ACTIVITY IN SMITH LAKE: University of Alaska, College.

The growth kinetics, substrate affinities, and organic nitrogen production of microorganisms isolated from Smith Lake will be determined under optimal and environmental conditions. These data will be correlated with enumeration studies in an attempt to estimate the role of microorganisms in the nutrient cycle of high arctic lakes.

Project Started: November 1965 (duration - one year).
Personnel: 1 microbiologist.
Principal Investigator: Dr. Sheril D. Burton.

Special Equipment: Bendix time of flight mass spectrometer, alpha, beta and gamma counters, Technicon Auto Analyzer.

6 DYNAMICS OF THE NITROGEN CYCLE IN LAKES: Institute of Marine Science, University of Alaska, College.

The project is concerned with measuring and evaluating the importance of the various transformations in the nitrogen cycle and their interrelationship with the primary productivity regime of a lake. Nitrogen-15 is used as a tracer in this work, and emphasis has been on the role of nitrogen fixation by blooms of algae in supplying nitrogen to the biological system. Currently the importance of loss of combined nitrogen by denitrification is being emphasized.

Project Started: August 1, 1964 (duration - to August 31, 1967).
Personnel: 1 chemist, 1 biologist.
Principal Investigators: R. C. Dugdale, V. A. Dugdale.

Special Equipment: Bendix time of flight mass spectrometer for Nitrogen-15 tracer work. Radioisotopes laboratory for Carbon-14 primary productivity.

Publications: Dugdale, V. A. and R. C. Dugdale. 1965. Nitrogen metabolism in Lakes III. Tracer studies of the assimilation of inorganic nitrogen sources. Limnol. Oceanogr. 10(1):53-57.

Dugdale, Vera Alexander. 1965. Inorganic nitrogen metabolism and phytoplankton primary productivity in a subarctic lake. Ph.D. thesis. University of Alaska, University Microfilms, Ann Arbor, Michigan.

BRITISH COLUMBIA

7 WATER POLLUTION IN THE OKANAGAN: Research Station, Summerland. Canada Department of Agriculture.

(1) Survey of BOD of effluents from municipal and trade waste sources which discharge into Okanagan Lake.

(2) Treatment parameters in apple processing plant waste. Determination of aeration and additives required to reduce BOD of waste as economically as possible.

Project Started: July 1965 (duration - 3-5 years).
Personnel: 1 microbiologist.
Principal Investigator: D. R. MacGregor.

8 BIOLOGICAL THRESHOLDS FOR POLLUTIONAL EFFECTS IN FISHES: Fisheries Research Board of Canada, Biological Station, Nanaimo.

Application of response surface methodology to the investigation of response domains under the influence of pollutants.

Objectives: Examination of

(1) Sub-lethal physiological responses to pollutants
(2) Determination of physiological optima
(3) Thresholds for maximum tolerance over a field of ancillary abiotic environmental variables.

Project Started: 1965.
Personnel: 1 biologist, 1 technician.
Principal Investigator: D. F. Alderdice.

Publications: Alderdice, D. F. 1963. J. Fish. Res. Bd. Can. 20(2):525-550.

Alderdice, D. F. 1963. Ph.D. Thesis, Univ. Toronto, Toronto, Ontario.

Alderdice, D. F. 1965. Biological problems in water pollution. Trans. 3rd Seminar. Cincinnati, Ohio. pp. 320-325.

9 PHYSICAL AND CHEMICAL OCEANOGRAPHY OF VICTORIA HARBOUR, THE GORGE AND PORTAGE INLET: Fisheries Research Board of Canada, Biological Station, Nanaimo.

Portage Inlet is a shallow marine embayment connected to Victoria Harbour by a narrow gut which is eminently constricted at the Gorge Narrows. Urban and agricultural drainage have introduced much nutrient into Portage Inlet, which has dense growth of attached and floating vegetation. Preliminary investigations show that there is a unique imbalance in certain nutrients during the summer with very high phosphate and low nitrate concentrations. Salinities in August were higher in Portage Inlet than in the deep waters of Victoria Harbour, indicating higher evaporation than runoff and precipitation at this time of year.

Project Started: August 1965 (duration - 1 1/2 years).
Personnel: 1 oceanographer, 1 technician.
Principal Investigator: M. Waldichuk

10 SEASONAL CHANGES IN WATER PROPERTIES OF ALBERNI INLET UNDER WASTE LOADING FROM A KRAFT PULP MILL: Fisheries Research Board of Canada, Biological Station, Nanaimo.

The major deleterious effect of the kraft mill effluent in a poorly flushed inlet such as Alberni is a drastic reduction in dissolved oxygen concentration of the waters during late summer. Most of this effect appears to be due to decomposition of the dissolved constituents in the wastes, but there is growing evidence that some of the oxygen uptake may be caused by decay of the wood solids deposited in the sludge beds of shallow estuarine waters.

Project Started: June 1965 (duration - to October 1966).
Personnel: 1 oceanographer, 1 technician.
Principal Investigator: M. Waldichuk.

11 INCREMENTAL STRESSES IMPOSED ON SALMONIDS BY KRAFT PULP MILL WASTES; British Columbia Research Council, Vancouver.

Development of techniques for measuring incremental stresses imposed on salmonids by kraft pulp mill wastes. These techniques are to be used in assessing mill operation and design, evaluation of treatment systems and receiving bodies of water.

Project Started: 1964 (duration - 10 years).
Personnel: 1 chemist, 2-3 biologists.
Principal Investigator: Dr. C. C. Walden

Special Equipment: Fish laboratory.

11 (continued)

Publications: 1965. Pollution and toxicity characteristics of kraft pulp effluents. Tappi 48:136-141.

1965. Water pollution and the kraft pulp mill industry. Western Fisheries, October 1965.

12 EFFECT OF KRAFT PULP MILL DESIGN AND OPERATION ON EFFLUENT BOD VALUES: British Columbia Research Council, Vancouver.

Evaluation of the effect of pulp mill design and operation on effluent BOD values to permit operational and design changes intended to reduce total pollution loading.

Project Started: 1965 (duration - to 1966).
Personnel: 1 chemist, 1 biologist.
Principal Investigator: Dr. C. C. Walden.

13 STUDY OF THE BASIC METABOLISM OF THIOBACILLUS FERROOXIDANS: British Columbia Research Council, Vancouver.

The long-term goal of this research is to define the basic phenomena regulating the oxidation of ferrous iron and sulfur by the chemoautotrophic bacterium, Thiobacillus ferrooxidans, as related to the problem of acidic mine drainage. Extensive data have been collected on nutrient requirements, respiration rates have been examined for the utilization of soluble iron, sulfur and various compounds thereon. Intermediate metabolic pathways for the utilization of thiosulfate have been elucidated. Continuing studies involve the biochemical reactions of sulfide to thiosulfate to tetrathionate and the various enzyme systems associated therewith. It is anticipated that the information will prove useful to devising methods for the control or elimination of the organism in those areas where its activities in producing acidic drainage produces a water pollution hazard.

Project Started: June 1, 1964 (duration - to May 30, 1967).
Personnel: 2-3 microbiologists.
Principal Investigator: Dr. C. C. Walden.

Special Equipment: preparative ultracentrifuge, radioactive gas flow counter, absorption spectrophotometer.

Publications: Iron oxidation by the chemoautotroph, Thiobacillus ferrooxidans. Can. J. Microbiol. (In press).

Three manuscripts in state of preparation.

14 LEVELS OF LETHAL AND SUB-LETHAL EFFECT OF RAW AND TREATED NEUTRALIZED KRAFT PULP BLEACH WASTE ON SOCKEYE AND PINK SALMON IN THEIR FRESHWATER LIFE PHASES: International Pacific Salmon Fisheries Commission, New Westminster.

Experimental work is being done to describe the lethal, but especially sub-lethal toxic effects of neutralized kraft pulp mill bleach waste on adults, eggs, alevins, fry and smolts. Hematological and histological examinations are being made for sub-lethal effects. Growth rates of alevins and fry reared in neutralized bleach waste are being measured. The effect of neutralized bleach waste and model compounds from the waste on metabolic rate of alevins is being determined. Results of the foregoing experiments are being compared with controls and with results of identical experiments using biologically treated (i.e., activated sludge) neutralized bleach waste. It is proposed that ultimately interaction between toxic effects and stress caused by the environment will be elucidated.

Project Started: September 1963 (duration - several years).
Personnel: 1 engineer, 1 biologist, 1 technician.
Principal Investigator: James A. Servizi

Publications: Servizi, J. A., E. T. Stone and R. W. Gordon. Toxicity and treatment of kraft pulp bleach plant waste. Progress Report, International Pacific Salmon Fisheries Commission. (In press).

15 MONITORING WATER QUALITY OF THE FRASER RIVER WATERSHED: International Pacific Salmon Fisheries Commission, New Westminster.

The monitoring program consists of measuring nineteen pertinent chemical and physical characteristics of the water along with the bottom fauna of the stream bed. These measurements are made twice a year at all stations and monthly on two stations in the Lower Fraser. Stations are located at Vancouver, Mission, Hope, Quesnel, Prince George, Walhachin, Savona, and Kamloops on the Fraser River and Thompson River. The stations are set up to measure the effect of pollution from industrial and domestic growth on the water quality and biota of the Fraser Watershed. The object of the program is to preserve and protect the fishing industry from pollution from other industries. At present the program is designed to determine the effect of the rapidly expanding pulp industry on the biota and water quality of the Fraser River and Thompson River.

Project Started: Spring 1963 (duration - continuous).
Personnel: 1 engineer, 1 technician.
Principal Investigator: Richard Burkhalter

Special Equipment: One square foot, artificial substrate, bottom fauna sampling trays. Submerged for 30 day samples.

16 ACUTE TOXICITY BIO-ASSAYS, USING SOCKEYE SALMON FINGERLINGS, OF BIO-DEGRADABLE DETERGENTS AND RELATED COMMERCIAL LAUNDRY PRODUCTS: International Pacific Salmon Fisheries Commission, New Westminster.

The 96-hour median tolerance limit, using sockeye fingerlings, was determined for the following materials used in commercial laundries: 996 Universal Detergent, Blusour, Drytex, Perlite and Borochlor.

Project Started: December 1965 (duration - one month).
Personnel: 1 biologist.
Principal Investigator: James A. Servizi

CALIFORNIA

17 MEASUREMENT OF GAMMA ISOTOPES IN WASTEWATER: California Institute of Technology, Pasadena.

The pattern of gamma isotope concentrations in Los Angeles sewage was studies by scintillation spectrometry. A seasonal pattern was noted among the nuclides of fallout origin (Zr-95, Ru-103, Ce-141, Cs-137); concentrations rose from low levels to peak values during the month of December, and gradually fell off during the spring and summer to reach their original low levels in September. Cobalt-60 and cesium-137 also occurred occasionally as heavy slugs presumably discharged by some industry. The theory of converting gamma spectrograms into concentration estimates was developed, particularly with regard to the statistics involved when the estimates are based on photopeak dimensions.

Principal Investigator: Andrew L. Gram.

Publications: Gram, A. L., T. R. Folsom, G. J. Mohanrao. 1965. Studies of gamma radioactivity in sewage and seawater. Technical Memorandum EH-65-2, W. M. Keck Laboratory of Environmental Health Engineering.

18 STATISTICS OF ESTIMATING MICRO-ORGANISM CONCENTRATIONS BY THE DILUTION METHOD: California Institute of Technology, Pasadena.

The project objective is to improve upon the present standard procedure of interpreting dilution method data to get estimates of microorganism concentrations. The present procedure (maximum likelihood or "most probable number") does not lead to an efficient estimate and hence can lay no claim for optimality. Tables to replace the MPN values normally used will be computed, and these estimates will have the property of least mean square error for a given limited bias.

Principal Investigator: Andrew L. Gram.

19 BIOCHEMICAL STABILIZATION OF AQUEOUS SOLUTIONS OF ORGANIC COMPOUNDS BY UNSATURATED FLOW THROUGH POROUS MEDIA: California Institute of Technology, Pasadena.

In space voyages of longer than two weeks it will be necessary to recover, purify, and reutilize urine and washwaters. Inasmuch as the total dissolved solids in urine exceed 40,000 mg/l, some type of demineralization system is indicated. More than half of the solids will be organic and consequently difficult to separate by

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19 (continued)

evaporative processes, membrane dialysis, etc. It would be advantageous if the organic solids could be oxidized to inorganic constituents prior to demineralization. This project proposes to study and evaluate many of the parameters associated with the intermittent aerobic filtration of aqueous solutions or organic compounds, especially urine and its various constituents, in flow through unsaturated porous media. Specifically, it is the aim of the project to determine the pathways and rates of biochemical degradation for each major organic constituent of urine under these conditions of treatment.

Project Started: May 1965.
Principal Investigators: Jack E. McKee, Albert B. Pincince.

Publications: McKee, J. E. 1964. Liquid wastes and water potability in space vehicles. Conferences on Nutrition in Space and Related Waste Problems, NASA SP-70.

20 WASTEWATER RECLAMATION BY PERCOLATION AND GROUND WATER MOVEMENT: California Institute of Technology, Pasadena.

The reclamation of wastewater from municipal and industrial effluents represents one of the least costly methods of augmenting the limited water supplies of arid regions, such as southern California, provided the water can be rendered potable from esthetic and public-health viewpoints. A field study has been carried out for 27 months in the Whittier Narrows area where spreading basins with sub-surface sampling pans have been constructed to study percolation into the ground of a treated secondary effluent from the 12-mgd Whittier Narrows Water Reclamation Plant. Waters percolating to depths of 2, 4, 6, and 8 feet have been collected and analyzed on a weekly basis in regards to chemical and biological quality. Particular emphasis has been on the reduction of the synthetic detergent, alkylbenzenesulfonate (ABS), in the waters percolating through the zone of aeration in the soil. ABS is typical of the exotic synthetic chemical compounds that are refractory to biochemical degradation by ordinary waste treatment processes. A special study was also performed by adding a very high concentration of an attenuated Sabin polio vaccine to the influent of one of the test basins in order to measure quantitatively the removal of viruses by the percolation process. The addition of the vaccine was necessary because normal wastewater treatment removes viruses to a large extent and the remaining viruses are so small in number that quantitative analyses are very difficult. In addition to the field studies, multiple sand columns have been constructed in the laboratory. These columns are of a special design which permits the hydraulic load to be applied intermittently. For more than

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350 days, a comparative study was performed on the biological removal from a synthetic wastewater of the conventional ABS vs. the new synthetic detergent, linear alkane sulfonate (LAS). Changes in chemical and biological parameters were measured at four depths within the 26-inch columns.

Principal Investigators: Jack E. McKee, Francis C. McMichael.

Publications: McKee, J. E. and F. C. McMichael. First and second annual reports on wastewater reclamation at Whittier Narrows. September 1963 and 1964.

McMichael, F. C. A field study of water quality changes resulting from intermittent spreading of wastewater at Whittier Narrows, presented at the 36th Annual Meeting of the California Water Pollution Control Association at Fresno. April 24, 1964.

21 ADSORPTION OF VIRUSES: California Institute of Technology, Pasadena.

The need for removal or inactivation of viruses from water has been demonstrated beyond question by the presence of enteroviruses in sewage and proven epidemics from such sources. Techniques employed in the collection of viruses from sewage are far from satisfactory, since a major portion of the virus particles are adsorbed or entrapped on solid matter. The purpose of this investigation is to study the adsorption phenomenon of viruses to various adsorbents, such as activated carbon, diatomaceous earth, coconut charcoal, and sand. To execute this study a quantitative method of assaying enteroviruses present in water was developed. Initial studies were performed with Escherichia coli bacteriophage T-4 to give some insight to the problems involved. Sabin Type-3 polio virus has also been used in these investigations. The ability of adsorbed virus particles to be desorbed and become active infectious agents is being determined under two conditions. The first condition involves adsorption and desorption in an environment free of living organisms. The second is in the presence of living organisms as typically found in sewage. The anticipation is to develop a quantitative assay for enteroviruses in sewage and to reveal the mechanisms of adsorption and the fate of the adsorbed viruses.

Principal Investigators: John T. Cookson, Jr., and Wheeler J. North.

Publications: Cookson, John T., Jr. Virus assay in sewage, presented at meeting of Hawaii Water Pollution Control Association. June 23, 1965.

22 KELP HABITAT IMPROVEMENT PROJECT: California Institute of Technology, Pasadena.

Methods are being developed for restoring natural marine vegetation in areas where damage has apparently resulted from pollution by discharge of wastes from metropolitan areas. One technique with great promise involves grazer control. Of prime importance is the reduction of swarms of herbivorous sea urchins. The method of choice has been poisoning with quicklime which can be controlled so that urchins are killed without substantial damage to other organisms. This technique has passed from the experimental to the pilot stage and will be used on a large scale commercial basis in 1966. A second technique is under development and involves culturing small kelp on ropes in the laboratory with subsequent transplantation to the field. Pilot scale experiments have increased the productivity of the Point Loma kelp bed about 20-fold during the past year.

Principal Investigator: Wheeler J. North.

Publications: North, W. J., E. K. Anderson, V. D. Vacquier, and L. G. Jones. 1965. Annual Report, Kelp Habitat Improvement Project, California Institute of Technology. 70 pp.

23 MARINE WASTE DISPOSAL AND SEA URCHIN ECOLOGY: California Institute of Technology, Pasadena.

This investigation is studying possible food relationships between human wastes dispersed in the ocean and large populations of sea urchins that persist near discharge sites. Sediment collections and water samples are being collected in the field to determine the physical and chemical condition of the dispersed wastes. Nutritional studies are being made of urchins to see how much organic intake is needed to prevent starvation and to find out how rapidly they can incorporate fine sediments, suspended particles and dissolved organics.

Principal Investigator: Wheeler J. North.

24 EFFECTS OF IONIZING RADIATION ON AQUEOUS SOLUTIONS OF THE DETERGENT ALKYL BENZENE SULFONATE AND SEVERAL LOWER HOMOLOGS: California Institute of Technology, Pasadena.

A study was conducted of the degradation of benzene-, p-toluene-, and alkylbenzene-sulfonates under the action of ionizing radiation from a 3400-curie, Cobalt-60 irradiator. Effects of varying solute concentrations, pH, and dissolved oxygen concentrations were observed as functions of the energy absorbed by the solutions. The rates of oxygen depletion and the rates of hydrogen peroxide, enol, and sulfate production were followed by irradiating the solutions for

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varying periods of time. Results of the irradiations indicate that, in aerated solutions, the major mode of degradation is by desulfonation of the molecule. Degradation was accompanied by significant losses in oxygen, possibly a result of direct oxidation of the solute by radiation, rather than by free radical reactions, Enols were also found to occur, but at very low concentrations. The product formed as a result of desulfonation of benzenesulfonic acid appeared to be quinonoid rather than phenolic in nature. In deaerated solutions, enol yields were found to decrease, while sulfates were not observed. A more rapid decrease in the ultraviolet absorption peaks of these homologs in deaerated solutions was attributed to the formation of dimers. The study indicates that the use of radiation, as a water or wastewater treatment process for degrading organic compounds, would necessarily be limited to aerated solutions in situations where the large losses of oxygen would not be detrimental.

Principal Investigators: Jules B. Cohen, William R. Samples.

25 THE FATE OF SELECTED ORGANIC PESTICIDES IN WATER: California Institute of Technology, Pasadena.

The purpose of this investigation has been to ascertain the fate of certain pesticides once they reach a water supply. Two synthetic organic herbicides, viz., isopropyl N-(3-chlorophenyl) carbamate (CIPC) and 2,4-dichlorophenoxyacetic acid (2,4-D), were selected for this study. A particular pesticide may be removed from a waterway by a variety of natural processes. The principal avenues and the ones with which this research has been concerned are adsorption on particulate matter and biological degradation. In all the experimental work, radioactively labeled pesticides have been employed. A liquid scintillation counting procedure has provided a sensitive analytical technique for measuring the amount of pesticide remaining in a solution. The biological degradation study primarily deals with the herbicide CIPC. Experimental results indicate that the isopropyl portion of the molecule is degraded within 10 days, while the ring portion is only partially destroyed over a period of months. Ultraviolet spectographs of the samples support the hypothesis that the ring is broken, but a short chain molecule remains and is not degraded. Studies on 2,4-D indicated no significant degradation over a period of months. Adsorption of CIPC and 2,4-D on three types of standard clay minerals and activated carbon was investigated. Negligible adsorption occurred with the clay minerals. The data obtained from studies of the adsorption of CIPC on activated carbon enabled the investigators to establish the adsorption rate, capacity, bonding energy, and kinetics for the system. The final segment of the study involves the process of degradation of CIPC

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previously adsorbed on carbon. The results from these experiments are not available at this time.

Principal Investigators: Henry G. Schwartz, Jr., and William R. Samples.

26 SEWAGE RECLAMATION BY PRESSURIZED RECHARGE OF AQUIFERS: California Institute of Technology, Pasadena.

Reclaimed used water may in the future be a major water supply source. Investigations have been conducted on the reclamation potential of underground flow of reclaimed water after injection through a pressurized well. The use of treatment procedures in addition to normal secondary sewage treatment have also been investigated. These procedures include chlorination, coagulation, and various types of filtration. Initial conclusions drawn from this research include: (1) the concentration of oxidizing agents present limits the degree of removal of organic substances, (2) nitrate almost totally disappears, (3) bacterial and viral contaminations are not problems, and (4) water approaching the requirements of the USPHS Drinking Water Standards can be obtained by proper treatment and handling of the effluent.

Principal Investigator: William R. Samples.

Publications: Samples, W. R. Deepwell injection and underground pollution effects. Presented at Gordon Research Conference on Micro-chemical Contaminants in Water. June 1964.

27 DYNAMICS OF DENSITY-STRATIFIED GROUND WATER FLOW: California Institute of Technology, Pasadena.

A theoretical and experimental study was made of the stability and mixing of a density-stratified flow in a saturated porous medium. The objects of the study were to investigate the influence of density differences on the hydrodynamic dispersion coefficient and to determine why it was possible to have a denser fluid in apparently stable horizontal motion on top of a lighter fluid. Experiments in which lateral dispersion coefficients were measured disclosed that, for sodium chloride solutions of up to at least 1% concentrations, there was no influence on the dispersion from density differences. An analysis of the stability of the motion showed that such a flow was theoretically always unstable but that instability growth rates could be so low that a quasi-stable flow was induced. The results will have application in understanding the assimilation of waste waters into ground water. The study is

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continuing with emphasis on developing a better knowledge of the role of molecular diffusion in the dispersion phenomenon.

Principal Investigators: E. John List, Norman H. Brooks, Robert C. Y. Koh.

Publications: List, E. J. 1965. The stability and mixing of a density-stratified horizontal flow in a saturated porous medium. Ph.D. Thesis.

28 DISPERSION IN TURBULENT OPEN CHANNEL FLOW: California Institute of Technology, Pasadena.

As water utilization and production and disposal of waste products become more intensive in the United States, pollution becomes an ever greater problem in our rivers and estuaries. Of particular importance is the disposal in rivers, either by accident or design, of radioactive products. The mechanism by which flows in open channels disperse pollutants is imperfectly understood; results of field experiments have varied widely from test to test and from river to river. Attempts to verify the existing theory (by Taylor and others) have failed completely. Large discrepancies have been noted between results of laboratory and field experiments. The purposes of this project are: first, to test the existing theory and determine wherein it fails; second, to identify the dominant mechanisms responsible for dispersion in both laboratory and natural situations; and third, to establish a workable method whereby the dispersion characteristics of a natural system can be more clearly predicted from a knowledge of the hydraulic characteristics. The project includes participation in a field study being carried out by the U. S. Geological Survey in the Duwamish River and Estuary in the State of Washington. Support for further laboratory study will be provided by the U. S. Geological Survey (1965-66).

Principal Investigators: Norman H. Brooks, Hugo B. Fischer.

Publications: Fischer, Hugo B. 1964. Discussion of "Time of Travel of Soluble Contaminants," by Thomas J. Buchanan. J. San. Engng. Div. Am. Soc. Civ. Engrs., Dec. 1964, pp. 129-130.

Fischer, Hugo B. 1965. Discussion of "Numerical Solution to a Dispersion Equation" by N. Yotsukura and M. B. Fiering. J. Hydraul. Div. Am. Soc. Civ. Engrs., March 1965, pp. 402-407.

Fischer, Hugo B. 1965. Discussion of "Estuarine Water Quality Management and Forecasting" by R. V. Thomann and M. J. Sobel. J. San. Engng. Div. Am. Soc. Civ. Engrs., June 1965.

29 DYNAMICS OF DENSITY-STRATIFIED RESERVOIRS: California Institute of Technology, Pasadena.

A theoretical and experimental study has been made of flow in a density-stratified reservoir when the fluid is withdrawn from a line sink at the end of the reservoir. During the past year, a viscous, diffusive theory for flow to a point sink has also been obtained with some experimental verification. An approximate integral theory, valid for somewhat larger flow rates, has been developed for both the two-dimensional and axisymmetric cases. This approximate theory checks with all the experimental results. The results of this research will be applicable to the management of water supply reservoirs when they are stratified, because layers of water may be withdrawn selectively at different times to control downstream river temperature and chemical quality of the water. Complementing the above work on withdrawal, research is continuing on the problem of discharge into a stratified fluid environment. When buoyant jets (or plumes) are generated from point and line sources in a stratified ambient fluid, the fluid rises only to some equilibrium level, then spreads in a thin cloud. Variables include angle of discharge and the horizontal velocity component of the ambient fluid. Results check quite well with the few experiments performed. This aspect of the work is applicable to pollution control problems in lakes and oceans. Some exploratory work has been started on the problem of a two-dimensional, impulsively started, non-buoyant horizontal jet into a stratified ambient fluid. A forward wake is clearly visible in the experiments.

Principal Investigators: Robert C. Y. Koh, Norman H. Brooks.

Publications: Koh, R. C. Y. 1965. Viscous stratified flow towards a sink. Journal of Fluid Mechanics (in press).

Brooks, N. H. and R. C. Y. Koh. Discharge of sewage effluent from a line source into a stratified ocean. Submitted for XI Congress, International Association for Hydraulic Research, Leningrad. September 1965.

30 SEDIMENTATION FROM TURBIDITY CURRENTS: California Institute of Technology, Pasadena.

This project extended from June 1964 to August 1965 and consisted of two phases. In the first, an investigation was made of the motion of the head of a density current, consisting of a salt solution flowing down a slope beneath fres water. It was found that the velocity of the head could be related to the velocity and Froude number of the uniform flow established behind the head. At large Froude numbers the velocity of the head is smaller than the velocity of uniform flow, owing to loss of salt solution by mixing at the head. In the second phase of the investigation, turbidity currents

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were produced by using surges composed of suspensions of plastic beads (density 1.52) released from a lock into a horizontal channel. Sediment deposited from the decelerating surge was sampled in order to study the effect on the size distribution of different initial concentrations and velocities. Slow motion moving pictures permitted detailed qualitative study of the processes of deposition.

Principal Investigator: Gerard V. Middleton, Division of Geological Sciences.

31 USE OF HIGH T.D.S. WATERS BY BLENDING: Los Angeles Valley College, Los Angeles.

This study is associated with the use of normally high T.D.S. ground water by blending with water from a salt water conversion plant and/or sewage treatment plant effluent. This blended water may be used for either domestic or agricultural purposes.

Project Started: December 1964 (duration - to 1966).
Personnel: 1 engineer, 3 engineering geologists.
Principal Investigator: Dr. J. E. Slosson.

32 GROUND WATER SUPPLY, EMERALD BAY, CATALINA: Los Angeles Valley College, Los Angeles.

This study is associated with the development of a ground water supply for residential use on Catalina Island.

Project Started: December 1964 (duration - to 1966).
Personnel: 3 engineering geologists.
Principal Investigator: Dr. J. E. Slosson.

33 EROSION CONTROL OF URBAN LAND AREAS: Los Angeles Valley College, Los Angeles.

This study is associated with erosion control, causes, and effects upon urban land development in Southern California.

Project Started: June 1959 (duration - continuing).
Personnel: 3 engineering geologists.
Principal Investigator: Dr. J. E. Slosson.

Publications: Parson's Landing Landslide. To be published by the Association of Engineering Geologist, Spring 1966.

34 EVALUATION OF WATER POLLUTION POTENTIAL OF THE CLEAR LAKE AREA OF LAKE COUNTY: Sacramento State College, Sacramento.

Clear Lake, California, is a natural fresh water recreational lake created by a volcanic dike across the upper Cache Creek drainage channel. The presence of hot and cold mineral springs has made it a favorite vacation and recreational area of many. Other major beneficial uses include municipal and domestic water supply, irrigation and fish propagation. Waste disposal by public and private systems has resulted in localized water pollution conditions posing hazards to the public health and adverse effects on fish, wildlife, and recreational activities. The objective of this study is to provide an inventory of waste discharges in areas contiguous to Clear Lake and in waters tributary to the lake. This supplements previous water quality investigations conducted at Clear Lake for basic use in formulating waste discharge policy for the Clear Lake Basin area. The project study entails the location, identification and characterization of existing waste discharges to evaluate potential surface and subsurface drainage into the lake. The reduced data will be evaluated to determine the potential impact of anticipated quantities and characteristics of waste discharges on the receiving waters.

Project Started: July 1, 1965 (duration - to June 30, 1966).
Personnel: 3 engineers, 1 stenographer, 1 keypunch operator.
Principal Investigator: Professor Leonard W. Hom.

Special Equipment: Aerial photographic equipment utilizing Ektachrome and Infrared films in the assessment of water quality characteristics.

Publications: California Department of Water Resources, Bulletin 94-13. Land and Water Use in Putah-Cache Creek Basins Hydrographic Unit. Volumes I and II (1965).

35 A DYNAMIC MODEL FOR WATER QUALITY CONTROL: Sacramento State College Foundation, Sacramento.

The long-term objective of this project is to develop a dynamic model for water quality control. This model will aid water quality managers in planning facilities to achieve or maintain water quality objectives as quantities and qualities of generated wastes change in the future. Current investigation is studying the influence of three factors on the costs of waste treatment:

(a) Growth of municipalities and industries.
(b) Entrance and exit of firms.
(c) Changing conditions in the receiving waters, such as variations in flows, temperatures, reaeration and deoxygenation.

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Project Started: January 3, 1966 (duration - 1 year).
Personnel: 1 engineer.
Principal Investigator: Kenneth D. Kerri.

Publications: Kerri, Kenneth D. 1965. An investigation of alternative means of achieving water quality objectives. Doctoral dissertation, Department of Civil Engineering, Oregon State University, Corvallis. 177 pages.

Kerri, Kenneth D. An economic approach to water quality control. Paper presented at Water Pollution Control Conference, Atlantic City, New Jersey, October 10-14, 1965. 32 pages.

36 PESTICIDE DISTRIBUTION AND DEGRADATION IN WATERWAYS: Stanford University, Palo Alto.

The aim of this research is to evaluate the significance of sorption and biodegradation on the distribution and movement of pesticides through soils and in streams and lakes.

Project Started: September 1, 1964 (duration - to August 31, 1967).
Personnel: 3 engineers, 1 chemist.
Principal Investigator: Perry L. McCarty.

Special Equipment: 2 electron capture and 1 microcoulimetric gas chromatographs.

37 ANAEROBIC WASTE TREATMENT KINETICS: Stanford University, Palo Alto.

To evaluate the kinetics of the anaerobic waste treatment process so that process design might be improved to obtain optimum loadings and maximum efficiency of treatment.

Project Started: September 1, 1962 (duration - to August 31, 1966).
Personnel: 2 engineers, 1 chemist.
Principal Investigator: Perry L. McCarty.

Publications: Kinetics of waste assimilation in anaerobic treatment, Society for Industrial Microbiology, August 1965.

38 WATER ECONOMICS IN THE PULP AND PAPER INDUSTRY: Stanford University, Civil Engineering Department, Palo Alto.

The project objective is the study of water costs of the industry. This includes water and waste processing requirements and costs as

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well as the special costs involved. Relationships within the water and waste cost functions will be considered in an effort to identify the economically important characteristics of the industry's practice in water use.

Project Started: July 1, 1962.
Personnel: 2 engineers, 1 economist.
Principal Investigator: Dr. Rolf Eliassen.

Special Equipment: Use of the University Computation Center.

Publications: Progress Reports 2 and 3: June 1963.

39 STUDIES ON THE REMOVAL OF VIRUS BY FILTRATION: Stanford University, Palo Alto.

Objectives: To determine filter efficiency in the removal of virus from waste streams. This study will evaluate various filter media sizes, the effect of different commercial polyelectrolytes, and the efficiency of diatomaceous earth in virus removal.

Project Started: July 15, 1965 (duration - to September 25, 1966).
Personnel: 2 graduate students.
Principal Investigators: Dr. Rolf Eliassen, Dr. Paul Kruger, and Olivia Chen.

Special Equipment: High speed centrifuges, Model HR-1; electronic colony counter, precision linear and logarithmic ratemeter.

40 RECLAMATION OF REUSABLE WATER FROM SEWAGE: Stanford University, Palo Alto.

The purpose of the project is to demonstrate, on a pilot-plant scale, the conversion of treatment plant effluent into usable water through the use of ion-exchange techniques. The demonstration plant includes an activated sludge unit, a conventional sand filter, a diatomite filter, an ion exchange column and a storage pond to receive the reclaimed water. The specific object of the project is to reduce the amount of refractory materials in the subject water, with particular emphasis on the removal of nitrogen and phosphorus.

Project Started: September 15, 1962 (duration - through September 14, 1967).
Personnel: 2 engineers, 1 chemist, 2 technicians.
Principal Investigator: Dr. Rolf Eliassen.

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Special Equipment: Complete package-type rapid bloc activated sludge unit, conventional sand filter, diatomaceous earth filter, ion exchange column, effluent storage pond.

Publications: Eliassen, Rolf, Bruce M. Wycoff, and C. D. Tonkin. Ion exchange for reclamation of reusable supplies. J. Am. Wat. Wks. Assn., September 1965.

Wycoff, Bruce. Water renovation by ion exchange. California Water Pollution Control Assn. Meeting, April 1964.

Stanford Civil Engineering Technical Report No. 41, August 1964.

Stanford Civil Engineering Technical Report No. 49, January 1965.

Stanford Civil Engineering Technical Report No. 58, October 1965.

41 RESEARCH IN THE USE OF MATHEMATICAL STATISTICS TO EVALUATE ATTAINMENTS OF ATMOSPHERIC WATER RESOURCES PROGRAMS: Taft College, Taft.

The objective of this undertaking is to develop mathematical and statistical methods to evaluate the attainments of the Bureau of Reclamation's Atmospheric Water Resources Program in the Southern Sierra area of California, especially in the Kern River drainage basin and the Kern County area.

Project Started: June 1965 (duration - 2 years).
Personnel: 1 mathematician, 1 student assistant.
Principal Investigator: Lawrence E. Peahl.

42 ENVIRONMENTAL SURVEILLANCE PROGRAM FOR THE GEORGIA PACIFIC AND CROWN SIMPSON PULP MILLS, HUMBOLDT COUNTY, CALIFORNIA: Humboldt State College, Arcata.

A study of the marine environment off Samoa and Fairhaven before and during mill operation. The project includes study of benthic invertebrates, fish, crabs, and water chemistry.

Project Started: June 1965.
Personnel: 1 chemist, 3 biologists.
Principal Investigators: James Gast, George Allen, John DeMartini, and Fred Telonicher.

43 FAUNAL CONSTITUTION OF SOUTH SAN FRANCISCO BAY: **University of San Francisco, San Francisco.**

Distribution of faunal elements and the effect of wastes and other variables. Biomass estimate of different environmental patterns.

Project Started: 1961.
Personnel: 2 biologists.
Principal Investigator: Francis P. Filice.

44 DETERMINATION AND OCCURRENCE OF NITRATE IN WATER: **Fresno State College, Fresno.**

The increasing nitrate content of well water in the Fresno area is a threat to the health of livestock and people. It is also an important consideration in fertilization of soil that is irrigated with this water. Chemical analyses of identical samples by several laboratories have yielded conflicting results. A spectrophotometric method of analysis involving absorption in the ultraviolet range has been worked out in the Chemistry Department of the college. The various chemical methods heretofore used have been shown to have serious shortcomings. Indications are that the ultraviolet absorption and phenaldisulfonic acid methods can be made to give consistent results on both synthetic solutions and ground water. The former method is much less time consuming than the latter. Additional work will be done on the methods and a variation of the ultraviolet absorption method of analysis, attention will turn to the effects of the methods of collecting and storing samples before analysis and the seasonal, yearly and geographical variations of nitrate content. Both incoming irrigation water and well water in the Fresno area will be studied.

Project Started: 1962.
Personnel: 1 chemist, 1 soil scientist, 3 students.
Principal Investigator. R. W. Bremner.

Special Equipment: A Beckman DK-2 automatic recording spectrophotometer.

Publications: Two reports on Independent Study 190 in the Chemistry Department of Fresno State College are on file in the college library. Authors are: (1) Ronald E. Majors; (2) Fred Shore.

45 AN INVESTIGATION OF WATER AND SEDIMENT QUALITY AND POLLUTIONAL CHARACTERISTICS OF SAN FRANCISCO BAY: **University of California, College of Engineering, Berkeley.**

The primary objective of this investigation is to develop information and data which will permit quantitative resolution of the effects of

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waste discharge upon beneficial uses of San Francisco Bay and contiguous estuarine waters with particular emphasis on the fishery resource. This general objective shall include the following specific objectives:

(1) To collate, review, and evaluate existing reports relating to water pollution, fishery resources, and corollary biological and chemical data;
(2) To develop quantitative biological, chemical, physical and hydrographic descriptions of the Bay with due regard to seasons, tidal action, and fresh water inflow;
(3) To correlate these biological, chemical, physical, and hydrographic data with waste discharges and to determine, insofar as possible, the effects of these discharges on the beneficial uses of the Bay;
(4) To develop, if practicable, simple indices or parameters that can be used for a continuing monitoring program to evaluate quantitative future changes in the Bay.

Project Started: September 1960 (duration - to December 1966).
Personnel: 4 engineers, 3 mathematicians, 3 aides.
Principal Investigators: Prof. Erman A. Pearson and Prof. Robert E. Selleck.

Publications: A Comprehensive Study of San Francisco Bay, 1962-63, (Third Annual Report), Text and Appendices.

A Comprehensive Study of San Francisco Bay, 1963-64, (Fourth Annual Report), Text and Appendices.

Final Report, a Comprehensive Study of San Francisco Bay, Volume I, Physical, Chemical, and Microbiological Sampling and Analytical Methods.

46 FUNDAMENTAL FACTORS PERTINENT TO MICROBIOLOGICAL WASTE CONVERSION IN ISOLATED ENVIRONMENTS: University of California, Berkeley.

The objectives are:

(1) Determination of optimum conditions for algal growth, primarily with respect to geometry of light source;
(2) The design and operation of a specialized waste unit to obtain maximum waste treatment per unit of volume of weight of culture;
(3) The development and operation of an advanced model of the microterella;
(4) The determination of that combination of environmental factors which would bring about the most efficient functioning of the

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algatron (a growth unit in which a mechanically rotated algal culture is the essential feature) and the microterella with respect to gas exchange, waste disposal and treatment, and water exchange;

(5) The development of the design of a unit in which two 70-kg men could be made a part of a closed environmental system.

Project Started: 1961.
Personnel: 3 engineers, 1 chemist, 1 biologist, 1 microbiologist
Principal Investigator: Dr. W. J. Oswald.

Special Equipment: closed ecological system "microterella".

Publications: Golueke, C. G. and W. J. Oswald. 1963. Closing an ecological system consisting of a mammal, algae and nonphotosynthetic microorganisms. Am. Biol. Teach. 25(7).

Golueke, C. G. and W. J. Oswald. 1964. Role of plants in closed systems. A. Rev. Pl. Physiol. Vol. 15.

Golueke, C. G. and W. J. Oswald. 1966. The algatron, a novel microbial culture system. Sun Wk. 11(1).

Oswald, W. J. and C. G. Golueke. 1961. Man in space - he takes along his waste problem! Wastes Engng. 32(9).

Oswald, W. J. and C. G. Golueke. 1962. Environmental control studies with a closed ecological system. Proc. Inst. Envir. Sci.

Oswald, W. J. and C. G. Golueke. 1964. Closed ecological systems. J. San. Engng. Div. Am. Soc. Civ. Engrs.

47 NUTRITIONAL AND DISEASE TRANSMITTING POTENTIAL OF SEWAGE GROWN ALGAE; University of California, Berkeley.

Algae are grown in a sewage in a 2/3-acre algal production-waste treatment pond. The algal crop is harvested in three steps:

(1) Initial concentration by centrifugation or by chemical precipitation;
(2) Dewatering the slurry from step 1 to a paste by means of a solid bowl centrifuge;
(3) Drying the paste on a steam-heated drum dryer.

The algal product is sent to University of California at Davis campus where feed trials with the material are run with lambs, hogs, and steers as the test animals. The quality of the reclaimed water is determined at the Sanitary Engineering Laboratory of the University according to conventional sanitary analyses. The concentration activity of pesticides by algae when grown in waste waters is also being investigated.

Project Started: 1962.
Personnel: 3 engineers, 1 chemist, 1 biologist, 1 microbiologist.
Principal Investigator: W. J. Oswald.

Special Equipment: 2/3-acre high rate pond.

Publications: Golueke, C. G., W. J. Oswald, and H. K. Gee. 1964. Harvesting and processing sewage-grown planktonic algae. Univ. of Calif. San. Eng. Res. Lab., College of Engineering and School of Public Health, SERL Report No. 64-8.

Golueke, C. G., W. J. Oswald and H. K. Gee. 1965. Harvesting and processing sewage-grown planktonic algae. J. Wat. Pollut. Control Fed.

Golueke, C. G., W. J. Oswald, and H. K. Gee. 1966. Effect of nitrogen additives on algal yield. J. Wat. Pollut. Control Fed. (In press).

Oswald, W. J. and C. G. Golueke. Eutrophication trends in the United States, a problem? Presented before the Water Pollution Control Federation, Atlantic City, New Jersey, October 11, 1965.

Oswald, W. J. and C. G. Golueke. Algae production from waste. Proc. 18th Annual California Animal Industry Conference, Fresno. October 25, 1965.

Oswald, W. J., C. G. Golueke, R. C. Cooper, J. H. Meyers, H. Hintz, and H. K. Gee. 1964. Nutritional and disease transmitting potential of sewage-grown algae. First Progress Report, WP 00026 R1-R2-R3, SERL Report No. 64-6.

48 EPIDEMIOLOGY OF EPIDERMAL TUMORS IN THE ENGLISH SOLE, PAROPHRYS VETULUS: University of California, Berkeley.

This project is studying the occurrence of tumors on the English Sole (*Parophrys vetulus*) found in San Francisco Bay and northern coastal waters of California. This investigation includes a study of the environmental aspects of this disease in fish, a determination of the causative agent and if the agent is associated with the discharge of domestic and industrial wastes into San Francisco Bay

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and other marine locations.

Personnel: 1 biologist, 2 microbiologist.
Principal Investigator: Dr. Robert C. Cooper.

49 SOILS, PESTICIDES AND THE QUALITY OF WATER: University of California, Davis.

Project Objectives:

(1) To establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground waters.
(2) To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils.
(3) To ascertain the solubility characteristics of pesticides sorbed on soil particles and hence the effect of suspended soil on the concentrations of pesticides in water.
(4) To ascertain the effects of management of pesticide and land on the transport, by all means, of pesticides to water supplies.

Project Started: 1965 (duration - to 1969).
Personnel: 2 water and soil scientists.
Principal Investigator: J. W. Biggar.

50 PROCESSES AND CONDITIONS CONTRIBUTING TO THE DETERIORATION OR IMPROVEMENT IN QUALITY OF GROUND WATER: University of California, Davis.

Project Objectives:

(1) To study the effect of irrigation management in salt-affected soils on the concentration and composition of effluents.
(2) To determine the effect of slightly soluble minerals in soils on the solute composition and concentration of percolating waters.

Project Started: 1963 (duration - one year).
Personnel: 1 water scientist.
Principal Investigator: L. D. Doneen.

Publications: Doneen, L. D. Properties of deep substrata in the West Side of San Joaguin Valley, California. Submitted for publication to HILGARDIA.

50 (continued)

Tanji, K. K., G. R. Dutt, J. L. Paul, and L. D. Doneen. A computer method for predicting salt concentration at variable soil water content. Submitted for publication to HILGARDIA.

Tanji, K. K., L. D. Doneen, and J. L. Paul. Predictions on the quality of water percolating through stratified substrata by computer analysis. Submitted for publication to HILGARDIA.

51 WATER QUALITY IN RELATION TO THE PHYSICAL AND CHEMICAL PROPERTIES OF SOILS: University of California, Davis.

Project Objectives:

(1) To determine the effect of various salts and their concentration in irrigation water on soil structure and infiltration rates.
(2) To determine the degree of accumulation of harmful salines in the soil from various irrigation waters and the quantity of leaching water required to maintain a productive soil for agricultural crops.
(3) To relate (a) the precipitation of salts to the potential salinity of the water and (b) salt concentration and sodium content to a permeability index for selected soils.
(4) To determine the role magnesium plays, when the water or soil contains large amounts of this ion, on plant growth, permeability of the soil, and its reclamation.

Project Started: 1963 (duration - indefinite).
Personnel: 1 chemist, 1 water scientist.
Principal Investigator: L. D. Doneen.

Publications: Tanji, K. K. and L. D. Doneen. Quantitative prediction of $CaCO_3$ precipitation in HCO_3^- salt solutions undergoing progressive reduction in volume. Accepted for publication in Soil Science Society of America Proceedings.

52 INORGANIC AND ORGANIC IMPURITIES OF IRRIGATION WATERS AFFECTING SOIL PROPERTIES AND PLANT GROWTH: University of California, Davis.

Project Objectives: To determine the effects of dissolved and suspended mineral and organic materials contained in irrigation waters on soils and plants. Investigation will include:

(1) The effects of kinds and concentrations of salts on soil structure and penetration of irrigation waters into soil.
(2) Effects on plants of materials dissolved in irrigation waters.
(3) The degree of accumulation of harmful salines in the soil as

52 (continued)

affected by (a) kinds and concentrations of salts in the water, (b) soil conditions, (c) climatic conditions, and (d) practices of growers.

(4) A study of the suitability of sewage effluents and drainage waters as irrigation waters. Sewage, drainage, and natural waters have many properties in common, but sewage and drainage waters also contain materials which are not found in natural waters.

Project Started: 1947 (duration - continuous).
Personnel: 1 water scientist.
Principal Investigator: L. D. Doneen.

Publications: Doneen, L. D. 1964. Notes on water quality in agriculture. Wat. Sci. Engng. Paper 4001.

53 VACUUM CUP EMISSION SPECTROGRAPHY AS A ROUTINE METHOD FOR QUANTITATIVE WATER QUALITY DETERMINATIONS: University of California, Los Angeles.

Project Objectives: To evaluate the vacuum cup electrode technique as a tool in the study of water quality, with emphasis in reducing cost and increasing sensitivity and accuracy for routine application of the method in determination of trace elements such as boron, zinc, manganese, and copper in water from widely varying sources.

Project Started: July 1, 1965 (duration - to June 30, 1966).
Personnel: 2 chemists.
Principal Investigator: A. F. Bush.

Special Equipment: Dual-Grating Bausch and Lomb Emission Spectrograph.

54 DISSOLVED SOLIDS REMOVAL FROM THIRD STAGE EFFLUENT AT HYPERION TREATMENT PLANT IN LOS ANGELES: University of California, Los Angeles.

A cooperative project with the City of Los Angeles' Bureau of Sanitation and UCLA Department of Engineering to study behavior of a sewage treatment process which would expand the usefulness of waste water. A tertiary stage algae pond was constructed and operated for three years in an effort to duplicate on a large scale the salt reduction demonstrated in a small pond on the UCLA campus. The objective was to allow algae to grow at a prolific rate and remove them from the water, thus improving water quality.

Project Started: September 1961 (duration - to June 1965).
Personnel: 5 engineers, 4 chemists, 1 microbiologist.

54 (continued)

Principal Investigator: A. F. Bush.

Special Equipment: An activated sludge pilot plant for reclamation of waste waters, approximate flow 15,000 gallons per day; a trickling filter system for treatment of waste water, approximately 15,000 gallons flow per day; chemical analytical facility; two algae ponds representing different scale operations which are compared in regard to their effectiveness in removing salts from waste water for reclamation purposes; electron microscope facility.

55 LEACHING REQUIREMENT AND SALINITY STUDIES WITH BEARING ORANGE TREES: University of California, Riverside.

Uniform quantities of water salinized to four compositions are being applied to Valencia orange trees. Soil salinity is being followed continuously and will be evaluated in terms of irrigation water composition and management. Leaf analysis and fruit production data will be collected and evaluation made.

Objectives:

(1) Evaluation of salinity in terms of fruit production and fruit quality.
(2) Appropriate irrigation management for waters of varied salinity.

Project Started: Spring 1965 (duration - 1972).
Personnel: 1 chemist, 1 technician.
Principal Investigator: Frank T. Bingham.

56 EFFECT OF TRACE ELEMENTS ON REUSE OF WATER: University of California, Riverside.

An important, but often overlooked, aspect of water pollution deals with agricultural waters and specifically with their contamination by salts derived from soils and geological formations or through human and industrial use. In the latter case recycling through the soil can greatly modify composition of waters important to plant, animal, and human health because (a) many are essential in extremely small amounts, and (b) excesses of some are known or suspected to be injurious.

Project Objectives:

(1) Establish the concentration of certain trace elements (Al, B, Ba, Cr, Cu, Mn, Mo, Ni, Pb, Sr, Y, Zn, and others as the need may arise and spectrographic techniques for their analysis can

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56 EFFECT OF TRACE ELEMENTS ON REUSE OF WATER: University of California, Riverside.

An important, but often overlooked, aspect of water pollution deals with agricultural waters and specifically with their contamination by salts derived from soils and geological formations or through human and industrial use. In the latter case recycling through the soil can greatly modify composition of waters important to plant, animal, and human health because (a) many are essential in extremely small amounts, and (b) excesses of some are known or suspected to be injurious.

Project Objectives:

(1) Establish the concentration of certain trace elements (Al, B, Ba, Cr, Cu, Mn, Mo, Ni, Pb, Sr, Y, Zn, and others as the need may arise and spectrographic techniques for their analysis can be developed) in the surface and ground waters of California;
(2) Relate trace element concentrations to the past history of the water, including geologic and use factors;
(3) Determine how trace element concentrations are modified upon passage of water through soils;
(4) Establish the effects of water composition and water-soil interactions on crop plants.

Project Started: January 1964 (duration - 3 years).
Personnel: 2 chemists.
Principal Investigator: Gordon R. Bradford.

Special Equipment: 3.4 M convertible direct reading spectrograph, atomic absorption spectrophotometer.

57 HYDROBIOLOGY OF AN ARTIFICIALLY FED ENCLOSED LAGOON AT THE UNIVERSITY OF CALIFORNIA, SANTA BARBARA: University of California, Santa Barbara.

The UCSB campus lagoon, which covers about 25 acres, has been closed to the sea for several years. It is maintained at constant level by effluent from the sea water system of the marine laboratory. Winter rains lower the salinity to less than 20°/00; but the excess of evaporation over precipitation during the summer creates a hypersaline environment. Northwesterly winds during the spring and early summer often cause noxious downwelling and anoxic putrification at the downwind end, although after a wet winter this influence is minimal. As would be expected in a small eutrophic lagoon, phosphates are high and most dissolved nitrogen is in the form of ammonia. The water grass Ruppia and green alga Enteromorpha predominate plant life. Enteromorpha spreads during the winter and spring months of maximum transparency, but declines during late spring. The limnomedusan *Gonionemus vertens* occurs with the *Enteromorpha* bloom. Various insects and worms constitute the food sources of the two resident fishes, *Fundulus pawipinnis* and *Gillichyhys mirabiles*. Noxious conditions can be controlled inexpensively by dredging dead plants and by local aeration.

Project Started: June 1, 1963 (duration - to September 30, 1965).
Personnel: 3 biologists, 1 hydrobiologist.
Principal Investigator: Alfred W. Ebeling.

Special Equipment: Industrial Instruments Electrodeless Salinometer, Precision Scientific Galvanic Cell Oxygen Analyzer, Klett 2cm Colorimeter.

Publications: Todd, Eric S., A. Kier and A. W. Ebeling. *Gonionemus vertens* (Limnomedusae:Olindiidae). *Bull. Sth. Calif. Acad. Sci.* (In press).

Hydrological report in preparation.

58 STUDIES ON THE ECOLOGY OF BENTHIC MARINE ALGAE: University of California, Santa Barbara.

Scuba diving techniques are employed to survey, map and describe communities of larger benthic marine algae off the southern California coast. Measurement of and descriptive accounts of the structure and seasonal changes related to the vegetation are underway. The study is centered off Anacapa Island - an unpolluted area some distance from the mainland. The study is primarily a descriptive one at present, although a number of benthic algae are being grown under different conditions in the marine laboratory on campus.

Project Started: September 1963 (duration - continuing).
Personnel: 2 biologists.
Principal Investigator: M. Neushul.

Special Equipment: Diving equipment (underwater communications gear) and underwater photographic gear.

Publications: Neushul, M. 1965. Scuba diving studies of the vertical distribution of benthic marine plants. Proc. 5th Mar. Biol. Symposium, Goteborg 1965. Reprinted from *Botanica Gotheburgensa III*, pp. 161-176.

North, W. J. and others. 1964. An investigation of the effects of discharged wastes on kelp. Publication No. 26 State of California Water Quality Control Board.

59 BENTHONIC FORAMINIFERA RELATIONSHIP TO OCEAN POLLUTION: University of Southern California, Los Angeles.

The principal objective of this project is to show the relationship between the normal distribution patterns of benthonic foraminifera of the mainland shelf and the modification of these patterns around ocean outfalls. In order to show this, studies have been made of the distribution patterns of dead populations using empty tests and these patterns are then compared with the distribution patterns of living specimens.

Project Started: January 1, 1965 (duration - to December 31, 1966).
Personnel: 6 microbiologists.
Principal Investigator: Dr. Orville L. Bandy.

Special Equipment: Microscopes, IBM computer, emission spectrograph.

Publications: Bandy, O. L., J. C. Ingle, Jr. and J. M. Resig. 1964. Facies trends, San Pedro Bay, California. Bull. Geol. Soc. Am. 75:403-424.

Bandy, O. L., J. C. Ingle, Jr., and J. M. Resig. 1964. Foraminifera, Los Angeles County outfall area, California. Limnol. Oceanogr. 9:124-137.

Bandy, O. L., J. C. Ingle, Jr., and J. M. Resig. 1964. Foraminiferal trends, Laguna Beach outfall area. Limnol. Oceanogr. 9:112-123.

Bandy, O. L., J. C. Ingle, Jr., and J. M. Resig. 1965. Foraminiferal trends, Hyperion outfall, California. Limnol. Oceanogr. 10:314-332.

Bandy, O. L., J. C. Ingle, Jr. and J. M. Resig. 1965. Modification of foraminiferal distribution by the Orange County outfall, California. Ocean Science and Engineering, Transactions of Joint Conference, Marine Tech. Soc. and Am. Soc. Limnol. Oceanogr., Washington, D.C., ne 1965, pp. 55-76.

Resig, J. M. 1964. The southernmost occurrence of Elphidiella hannai (Cushman and Grant), 1927, off the west coast of North America. J. Paleont. 38(2):393-396.

60 FACTORS CONTROLLING UTILIZATION OF SANITARY LANDFILL SITE: University of Southern California, Los Angeles.

Instrumented landfills existing under controlled field conditions will be utilized to continue and expand the study of several facets of landfill use and performance. Included in the studies will be the effect of aeration, rainfall and controlled irrigation for turf support on settlement, temperature, humidity, percolation, gas quality, and refuse decomposition.

60 (continued)

Project Started: May 1, 1960 (duration - 8 years).
Personnel: 2 engineers, 3 graduate students.
Principal Investigator: Robert C. Merz.

Publications: Gas production in a sanitary landfill. Public Works 95(2):84, February 1964.

Factors controlling utilization of sanitary landfill site. First Progress Report to USPHS, March 1965.

61 TREATMENT OF BEET SUGAR WASTES BY PONDING: Beet Sugar Development Foundation, Ft. Collins, Colorado - Research conducted at Tracy, California.

Project Objectives: To evaluate lagooning as a means of treating beet sugar plume wastes. Project includes study of anaerobic, aerobic, and facultative environments.

Project Started: June 1965 (duration - 2 to 3 years).
Personnel: 1 engineer, 1 programmer, 2 laboratory assistants, 3 consultants.
Principal Investigator: James Fischer.

Special Equipment: Pilot plant lagoons (1) 1-acre anaerobic lagoon, (2) 2-acre facultative lagoon, and (3) 3-acre aerobic lagoon.

62 FOAM RECYCLE: Sanitation Districts of Los Angeles County, California, in cooperation with U. S. Public Health Service.

Project Objective: To investigate the foam recycle method of foamate disposal for a foam separation process. The effluent from the Saugus activated sludge waste water treatment plant is subjected to foam separation and the foamate recycled to the aeration basin inflow to determine if foamate reduction can be obtained.

Project Started: August 1965 (duration - to December 1965).
Personnel: 1 engineer, 1 chemist.
Principal Investigator: Max Augustus.

63 REFUSE TO SEWER STUDY: Sanitation Districts of Los Angeles County, California.

The primary objective of the project is to determine the feasibility of using a sewerage system as a transport vehicle for solid waste disposal, and the effects of the addition of refuse on the treatment process. The study is divided into two parts.

(1) Determine the settling characteristics of ground refuse in sewage, and
(2) Determine the digestibility of the resultant sludge-refuse mixture.

Project Started: February 8, 1965 (duration - 15 months).
Personnel: 1 engineer, 1 chemist.
Principal Investigator: Robert D. Whitley.

Special Equipment: Refuse grinder, pilot plant digesters.

64 ODOR CONTROL RESEARCH: Sanitation Districts of Los Angeles County, California.

Project Objective: To identify and evaluate sources of odors at the Districts' joint water pollution control poant and provide methods for controlling odor emission. An odor evaluation panel of 8 people has been set up to give quantitative values to odor levels. Initial research involved location of and quantitative evaluation of odor sources such as sludge digestion gas emission, sedimentation tank emission, and others. Pilot plant studies were then conducted to cost evaluate methods of removing odors from an odorous air stream. Odorous air scrubbing systems being evaluated include activated sludge, a floating bed scrubber using various chemicals, activated carbon and fume incineration. Identity of some of the odorous air compounds has been studied using gas chromatography. Preliminary research has shown that odor levels from the Districts' JWPCP are well within recommended air pollution limits.

Project Started: September 1964 (duration - through 1966).
Personnel: 1 engineer, 2 technicians.
Principal Investigator: Jay G. Kremer.

Special Equipment: Odor evaluation panel for quantitative odor measurement, instrument for measuring H_2S, mercaptans and disulfides.

65 RECREATIONAL REUSE STUDY: Sanitation Districts of Los Angeles County, California, in cooperation with U. S. Public Health Service.

Project Objective: Determine the most feasible method for renovating available sewage oxidation pond water for use in recreational lakes. The Lancaster-Palmdale area of the Antelope Valley proposed to create a water-based recreational site including 19 acres of lake area. Due to a local potable water shortage the renovation and reuse of oxidation pond water was proposed. The oxidation pond water contained large quantities of algae causing wide daily fluctuations in pH and dissolved oxygen content and preventing the maintenance of fish life. Removal of enough organic matter, algae and algae nutrients to allow a clear water regimen to become established was necessary. Extensive research was undertaken in three phases; collecting basic data on the character of the water, laboratory jar test evaluations of numerous chemical coagulants, and pilot plant operation of the most promising processes. Basic data collection has shown a definite seasonal variation in algae pond water characteristics which affected treatment costs and results. Of the numerous treatment methods tested, use of aluminum sulfate as the primary coagulant was found most economical to obtain turbidity, algae and phosphate nutrient reduction. Cationic polyelectrolytes were also found effective as coagulant aids.

Project Started: October 1963 (duration - through 1966).
Personnel: 2 engineers, 2 chemists, 1 laboratory technician, 2 laborers.
Principal Investigator: Gerald Stern.

Publications: Dryden, F. D. and G. Stern. 1965. Renovation of oxidation pond waters for recreational reuse. Presented before the 1965 annual conference of the California Water Pollution Control Association, San Diego. Calif. Wat. Pollut. Control Assn. Bull., October 1965.

U. S. Public Health Service, First Annual Report on Advanced Waste Treatment by the Sanitation Districts of Los Angeles County, 1965.

66 FOAM SEPARATION STUDY: Sanitation Districts of Los Angeles County, California, in cooperation with U. S. Public Health Service.

The foam separation study was designed to develop a prototype foam separation tank with optimum operating characteristics. Of particular interest was the possibility that the foam separation process would provide economical first stage

66 (continued)

tertiary treatment for the partial removal of suspended solids from activated sludge secondary effluents. In addition, the process removes residual ABS and COD. Anticipating the conversion from resistant to biodegradable surfactants, test runs were conducted featuring the addition of small concentrations of LAS to provide the necessary froth to achieve suspended solids removal. Pilot design variations for 1/2 to 1 mgd capacity foamers included single chamber horizontal flow and multiple-chamber counter-current flow patterns. Variables included detention time, air-liquid ratio, freeboard and concentrations of effluent constituents.

Project Started: August 1, 1963 (duration - to December 1965).
Personnel: 2 engineers, 1 chemist.
Principal Investigators: John Zoltek, Max Augustus, Robert Miele.

Publications: Joint PHS-LACSD Water Renovation Research Project, Interim Report Part II, Contract No. PH-86-63-214, July 1963 to July 1964.

67 DOMINGUEZ CHANNEL STUDY: Sanitation Districts of Los Angeles County, California.

Dominguez Channel has been utilized for the past 50 years for the disposal of storm runoff and industrial wastes to harbor waters and thence to the Pacific Ocean. Some 8.5 miles of the lower end of this water course are being deepened and widened for flood control purposes, creating a tidal channel 4-17 feet deep. Work on the lower 2/3 of the channel was completed about a year ago. Wide differences of opinion existed concerning the ability of the improved channel to assimilate industrial wastes during summer months when there would be no storm water runoff. Some thought that all industrial wastes should be diverted into public sewers. The high cost of sewer and treatment plant capacity (estimated current value $3,000,000) required adequate justification. A study made under summer conditions showed that the zone of maximum pollutional effects had moved from the mouth to the upper end of the channel. Nuisance levels no longer exist. The question of the improved channel's capability to continue to assimilate the industrial wastes presently being discharged to it was resolved in the affirmative. Sewer disposal is not required.

Project Started: July 1965 (duration - 6 months).
Personnel: 3 engineers, 1 chemist.
Principal Investigator: Dr. James Foxworthy.

68 DEVELOPMENT OF COST VS. QUALITY RELATIONSHIPS FOR WATER RENOVATION SYSTEMS: Sanitation Districts of Los Angeles County, California, in cooperation with U. S. Public Health Service.

Project Objective: Determine the relationships between treatment costs and effluent quality for several variations of the activated sludge process. The investigation was carried out in the Sanitation Districts' 12 mgd Whittier Narrows water reclamation plant. Evaluation was based on the relative BOD, COD, suspended solids, and turbidity of the effluent at various flow rates. The plant is unique in that plant flow can be controlled at almost constant rates while air rates and flow patterns are varied.

Project Started: October 1963 (duration - to December 1965).
Personnel: 1 engineer, 1 chemist.
Principal Investigator: John Zoltek.

Publications: Joint PHS-LACSD Water Renovation Research Project, Interim Report Part III, Contract No. PH-86-63-214, July 1963 to July 1964.

69 CARBON ADSORPTION STUDY: Sanitation Districts of Los Angeles County, California, in cooperation with U. S. Public Health Service.

Project Objective: To investigate the adsorption process using activated carbon on a pilot plant scale treating final effluent from the Pomona activated sludge plant. The feed to the beds of granular activated carbon was initially filtered through a diatomaceous earth filter but is now fed directly to the activated carbon columns. The feed may be subjected to various pretreatments such as coagulation, filtration, or foam separation. Carbon is regenerated on site and returned to the adsorption units. The efficiency of the adsorption process is measured by monitoring the feed and product for parameters such as COD, TOC, ABS, and others. Water quality is monitored at several points along the contactor to determine the optimum water residence times and carbon adsorption loadings. Loss of carbon through abrasion attrition and regeneration is measured by periodic carbon inventories. Auxiliary studies are being conducted to determine optimum activated carbon contactor design and operation.

Project Started: September 1964 (duration - to September 1968).
Personnel: 2 engineers, 3 chemists, 1 technician.
Principal Investigator: John English.

Special Equipment: total organic carbon analyzer, activated carbon regeneration furnace.

70 STRIPED BASS MORTALITY INVESTIGATION: California Department of Fish and Game, Sacramento, in cooperation with U.S. Geological Survey.

Large numbers of striped bass die annually during the spring months in the upper portion of San Francisco Bay. Preliminary studies indicate a toxic material is causing the mortality. The material may originate with a waste discharge or may result from a combination of factors including the interaction of wastes from one or more sources, the interaction of wastes and natural materials, and the physiology of the fish. The objective of the study is to determine the cause or causes of mortality to allow remedial action, if possible, and to allow us to predict the effect of various proposals for waste discharge or water development in the area.

Project Started: June 1965 (duration - approximately 12 months).
Personnel: 2 engineers, 4 chemists.
Principal Investigators: L. R. Dunham, W. Silvey, D. Lollock.

Special Equipment: spectrograph for analysis of minerals in water and gas chromatograph or infrared spectrograph for organic materials.

71 A STUDY OF DISSOLVED OXYGEN DYNAMICS IN THE SACRAMENTO-SAN JOAQUIN DELTA: California Department of Fish and Game and California Department of Water Resources, Sacramento, in cooperation with U. S. Geological Survey.

The objective is to define the relationships that exist between dissolved oxygen and various physical, chemical, hydrological, and biological parameters throughout the estuary. This information will be used to establish operating criteria for future water developments, so dissolved oxygen problems can be avoided in the estuary. The objective will be achieved by relating periodic measurements at a series of stations selected to represent varying conditions in the Delta. Parameters measured include phytoplankton, zooplankton, chlorophyll, light penetration and levels, water retention time and velocity, community production and respiration, and various chemical constituents.

Project Started: July 1965 (duration - to January 1968).
Personnel: 1 engineer, 1 chemist, 4 biologists.
Principal Investigator: Harold K. Chadwick.

Publications: Annual Report No. 4 - Delta Fish and Wildlife Protection Study, California Department of Fish and Game, Appendix B, June 30, 1965.

72 SANITARY LANDFILL STUDIES: California Department of Water Resources, Sacramento.

The objectives of this study are to determine the effects of decomposition products from refuse landfills on ground water and to develop plans or measures for the protection of ground waters from pollution.

Project Started: July 1962 (duration - 5 years).
Personnel: 1 engineer.
Principal Investigator: Gary A. Boulier.

Special Equipment: mobile pump unit, submersible pump, packers on pump for selected strata sampling.

Publications: Bulletin 147-5 - to be published in spring 1967.

73 DISPERSION AND PERSISTENCE OF SYNTHETIC DETERGENTS IN GROUND WATER, COLTON NARROWS, SAN BERNARDINO AND RIVERSIDE COUNTIES: California Department of Water Resources, So. Dist. Planning Branch, Sacramento.

The general objectives of this investigation are:

(1) To assist the Santa Ana River Basin Regional Water Quality Control Board in the conduct of its regulatory responsibilities.
(2) To determine the fate of synthetic detergents percolating into the ground waters.
(3) To develop fundamental data that will aid in the evaluation of mixing and dispersion of waters within a ground water basin.

The specific objectives are to determine the areal extent in the ground waters of synthetic detergents in the area of investigation and also the changes occurring during the study period; to determine the concentrations of synthetic detergents reaching the ground water from the unsaturated zone by percolation, and dispersion of synthetic detergents in the ground water body, and the persistence of synthetic detergents in ground water.

Project Started: January 1962 (duration - June 1967).
Personnel: 2 engineers, 2 chemists, 1 engineering geologist.
Principal Investigator: George P. Gribkoff.

Special Equipment: Packer equipped pump for selective depth sampling, device for collecting samples of percolating waters from the unsaturated zone at depths in excess of the capabilities of ordinary vacuum tensiometers, a modified infrared spectrophotometer.

Publications: Dispersion and Persistence of Synthetic Detergents in Ground Water, San Bernardino and Riverside Counties, September 1964.

74 PREPILOT BIOLOGICAL TREATMENT PLANT - SAN JOAQUIN MASTER DRAIN: California Department of Water Resources, Sacramento.

This is an engineering development project for removal of the algae growth potential from agricultural drainage waters. The major objective is to develop the construction, operation and maintenance costs; the design criteria; and the practicability and efficiency of biological treatment, both aerobic and anaerobic, of drainage waters. Incidental studies will include the changes in pesticide and mineral concentration related to the treatment processes. Also included will be a study of the biological growths that may be expected to occur in the drainage facilities and receiving waters. The reclamation of any treatment by-products (such as algae) will be investigated. Prediction of the initial and future characteristics of the waters of the Master Drain will also be included. The prepilot plant will include an algae growth pond, a digestion pond, a holding pond, separation study facilities, and a chemical and biological laboratory.

Project Started: July 1963 (duration - to January 1969).
Personnel: 3 engineers, 1 chemist, 2 biologists, 2 technicians, 3 consultants.
Principal Investigator: Louis A. Beck.

75 DISSOLVED OXYGEN DYNAMICS STUDY OF THE SACRAMENTO - SAN JOAQUIN ESTUARY: California Departments of Water Resources and Fish and Game, Sacramento, in cooperation with U. S. Geological Survey.

The project will develop relationships between (1) the fertilization of the surface waters with nitrogen and phosphorus from municipal, industrial, and agricultural wastes, (2) phytoplankton productivity with respect to time and space distribution, (3) oxygen relationships, (4) hydraulics, (5) water chemistry, and (6) fish populations in the estuary. Generally the objective of the study is to develop a working hypothesis under which the biology and chemistry of the estuary can be controlled to provide a suitable environment for optimum development of the fishery resources of the estuary, as the Peripheral Canal Project is constructed to convey surplus water of Northern California through the Sacramento - San Joaquin River Delta for export.

Project Started: July 1965 (duration - 3 years).
Personnel: 1 engineer, 1 chemist, 5 biologists.
Principal Investigator: Thomas E. Bailey.

Special Equipment: fluorometer, photometer and pyrheliometer, spectrograph, inverted microscope.

75 (continued)

Publications: Annual Report No. 4 (1964-65), Delta Fish and Wildlife Protection Study, The Effect of Water Development on the Delta Environment, The Resources Agency of California, 1965. (In press).

76 DELTA FISH AND WILDLIFE PROTECTION STUDY: California Department of Water Resources, Sacramento.

Study began July 1961, to determine the effects of water transport across the Sacramento - San Joaquin Delta on fish and wildlife as a Delta water facility is constructed as part of the State Water Project. This is a cooperative study by the Department of Water Resources and Department of Fish and Game; the agencies provide engineering and biological data respectively. During the past five years the study has (1) documented and more closely defined the ecology of the estuary, (2) established the effects of the proposed projects on the Delta, (3) assisted in the choice of that facility. The Peripheral Canal concept has now been chosen for the Delta Water Transfer Project. The emphasis of the study is now shifting from applied biological research to the area of how to operate the project. The study is presently involved in investigation of (1) neomysis in the Delta, (2) striped bass mortality, (3) local wetlands management (Suisun Marsh), (4) development of a fish ladder to pass striped bass, (5) development of a pump to lift live fish, and (6) dissolved oxygen dynamics.

Project Started: July 1961 (duration - to June 1968).
Personnel: 4 engineers, 15 biologists.
Principal Investigators: C. C. Coy, D. W. Kelly, H. K. Chadwick.

Special Equipment: analog model of Delta, analog computer, striped bass ladder test facility, air lift pump (fish ladder), a future test facility.

Publications: Annual Reports No. 3 (1964 and No. 4 (1965).

Investigation of the Sacramento, San Joaquin Estuary, Vol. 1 and 2 (1965), published by California Department of Fish and Game.

77 DELTA-SUISUN BAY POLLUTION INVESTIGATION: Department of Water Resources, San Francisco Bay District.

This investigation is part of the water quality portion of the overall planning of the State of California's water project and includes estimation of water quality changes resulting from the

77 (continued)

San Joaquin Master Drain. The general objective of the investigation is to characterize present natural and man-made sources of water quality degradation, to determine their effect on water quality in the waterways of the Sacramento-San Joaquin Delta-Suisun Bay area, and to evaluate these and future sources with respect to operation of the Delta Water Facility and San Joaquin Valley Drainage Facility.

Project Started: 1961 (duration - to June 1966).
Personnel: 4 engineers.
Principal Investigator: W. M. Gibson.

Special Equipment: equipment for fluorescent dye tracer studies in an estuary.

Publications: Delta-Suisun Bay Pollution Investigation. Bulletin No. 123, State of California, 1966.

Bailey, T. E. 1965. Observations on the Limnology of a Polluted Reach of an Estuary. Presented at the 46th Annual Meeting, Pacific Division, American Association for the Advancement of Science, June 25, 1965.

Office Reports of San Francisco Bay District of the Department of Water Resources: Water Transport Through the Cross Delta Channels; Hydraulic Characteristics of Mokelumne River System; Hydraulic Model Studies of Effects of San Joaquin Valley Drainage Facilities; Environmental Characteristics of Three Dead-End Sloughs; Delta Water Quality; Delta-Suisun Bay Waste Discharge Inventory and Projection.

78 DELTA-BAY WATER QUALITY INVESTIGATION: Department of Water Resources, San Francisco Bay District.

The objectives of this investigation are to determine the following within the San Francisco, San Pablo, and Suisun Bays:

(1) Existing nutrient and pesticide concentrations and related water quality factors through evaluation of existing data and limited field studies.
(2) Adequacy of monthly grab sampling in a cross-section, with particular emphasis on ecological parameters.
(3) Flow characteristics and assimilative capacity of the system using dye tracer techniques.
(4) The mode of pesticide transport.

Project Started: June 1965 (duration - to 1969).
Personnel: 4 engineers.
Principal Investigator: W. M. Gibson.

79 WATER QUALITY REPORT ON PAUMA, PALA, AND BONSALL GROUNDWATER BASINS: California Department of Water Resources, San Diego Regional Water Quality Control Board.

An investigation of basic hydrology, geology, and groundwater quality in portions of the San Luis Rey River Basin.

Project Started: July 1960 (duration - to December 1965).

80 ECOLOGICAL SURVEY OF KELP BEDS NEAR POINT LOMA: San Diego Regional Water Quality Control Board.

An investigation and report on the physical condition, biological activity, and stage of development of kelp beds in the Pacific Ocean in vicinity of Point Loma, for the purpose of providing surveillance information subsequent to the inception of a community waste discharge in the area through a submarine outfall.

Project Started: August 1964 (duration - to September 1965).
Principal Investigator: Dr. Wheeler J. North.

81 THE MARINE ENVIRONMENT OFFSHORE OF POINT LOMA, SAN DIEGO COUNTY; San Diego Regional Water Quality Control Board.

Investigation of the marine ecology along the western shore of Point Loma from the intertidal zone to the 100-foot depth by diver-biologists. Acquire data to aid in describing and evaluating the effect of a large municipal sewage outfall.

Project Started: February 1965 (completed in 1965).
Principal Investigators: Charles H. Turner, E. E. Ebert, and R. R. Given.

82 GROUNDWATER CONDITIONS IN SAN DIEGO RIVER VALLEY: California Department of Water Resources, San Diego Regional Water Quality Control Board.

An investigation of the basic geology, hydrology, and ground and surface water quality in the middle reach of the San Diego River.

Project Started: July 1959 (duration - to September 1965).

83 WATER QUALITY INVESTIGATION OF MONTEREY COUNTY, INCLUDING RECOMMENDED QUALITY OBJECTIVES FOR SURFACE AND GROUND WATERS: California Department of Water Resources, Regional Water Quality Control Board, San Luis Obispo.

Objectives:

(1) Determine present quality of surface and ground waters.
(2) Determine occurrence, utilization, and movement of both surface and ground waters, particularly as they may be affected by waste discharges.
(3) Determine quality of existing sewage and industrial waste discharges and the effect they may have on water quality.
(4) Recommend realistic mineral water quality criteria for maximum beneficial use of surface and ground waters.
(5) Recommend wells suitable for monitoring: (a) water quality of basin, and (b) effects of existing waste discharges. Present general information regarding monitoring ground waters in the vicinity of future waste discharges.

Project Started: 1965 (duration - one year).

84 WATER QUALITY INVESTIGATION OF SAN LUIS OBISPO COUNTY COASTAL PLAIN, INCLUDING RECOMMENDED QUALITY OBJECTIVES FOR SURFACE AND GROUND WATERS: California Department of Water Resources, Regional Water Quality Control Board, San Luis Obispo.

Objectives:

(1) Determine present quality of surface and ground waters.
(2) Determine occurrence, utilization, and movement of both surface and ground waters, particularly as they may be affected by waste discharges.
(3) Determine quality of existing sewage and industrial waste discharges and the effects they may have on water quality.
(4) Recommend realistic mineral water quality criteria for maximum beneficial use of surface and ground waters.
(5) Recommend wells suitable for monitoring: (a) water quality of basin, and (b) effects of existing waste discharges.

Project Started: 1965 (duration - one year).

85 SANTEE RECREATION PROJECT: FWPCA, Region IX, San Francisco, in cooperation with California agencies.

This seven-agency cooperative study evaluated the fate of viruses along with bacterial indicators, physical and chemical quality data through a conventional secondary treatment process, additional

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tertiary processes, and recreational lakes deliberately designed to utilize the community's reclaimed sewage effluent. The study presented convincing evidence that allowed the state and local health authority and the Water District to increase the recreational program until a water contact swimming program was conducted during the 1965 summer season. The program met with complete public acceptance. This cooperative study also evaluated the eutrophication problems and ecological relations that developed from the use of waste water in this manner.

Project Started: February 1962 (duration - to June 1966).
Personnel: 1 engineer, 1 biologist.
Principal Investigator: John C. Merrell, Jr.

Publications: Santee Recreation Project Summary Report. USPHS Environmental Health Series Publication, 1965.

86 SAN FRANCISCO BAY AND SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA, WATER QUALITY AND WASTE DISPOSAL STUDY: Department of the Army, Corps of Engineers.

Authorizing Legislation of Congress: Section 216 of the Flood Control Act of 1965 which is quoted below:

> (1) The Secretary of the Army is hereby authorized and directed to cause to be made, under direction of the Chief of Engineers, an investigation and study of San Francisco Bay, California, including San Pablo Bay, Suisun Bay and other adjacent bays and tributaries thereto, with a view to determining the feasibility of, and extent of Federal interest in, measures for waste disposal and water quality control and allied purposes.

Supplemental Authority: House of Representatives Committee on Public Works resolution, adopted May 8, 1964, which is quoted below:

> (2) Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports on Sacramento, San Joaquin and Kern Rivers, California, published as House Document 191, 73rd Congress, Second Session, and other reports, with a view to determining the feasibility of remedial measures for water quality control and other purposes, included in comprehensive development of the Sacramento-San Joaquin Delta, including verification of conclusions by model analysis as deemed necessary.

86 (continued)

Project Started: Fiscal Year 1966 (duration - 5 years).

Special Equipment: Existing tidal hydraulic model of entire San Francisco Bay system and portion of ocean outside Golden Gate, constructed to vertical scale of 1:100 and horizontal scale of 1:1,000.

87 PRECIPITATION OF $CaCO_3$ AND ACCUMULATION OF EXCHANGEABLE Na FROM IRRIGATION WATERS AS INFLUENCED BY LANGELIER'S pH VALUES AND LEACHING PERCENTAGE: USDA - ARS - SWC, U. S. Salinity Laboratory, Riverside.

The objectives of this research are:

(1) To determine the amount of $CaCO_3$ which precipitates in soil irrigated at various leaching percentages with waters having various theoretical pH values at equilibrium with $CaCO_3$ (pH_c);

(2) To study the interactive effects of the SAR and the pH_c value of the irrigation water, and the leaching percentages of the accumulation of exchangeable Na.

Twenty-four lysimeters have been filled with a nonsodic, calcareous soil, planted with Harding's grass, and are being irrigated with six different waters (variable total salt concentration and composition) and at four different leaching percentages. Following each irrigation, the volume and the Ca, Mg, Na, and HCO_3 concentrations of the leachates from each lysimeter will be determined. Precipitation of $CaCO_3$ and exchangeable Na accumulation will be determined and evaluated with respect to quality of irrigation water and the leaching percentage used.

Project Started: January 1964 (duration - to June 1967).
Principal Investigators: C. A. Bower and G. Ogata.

Special Equipment: 24 lysimeters.

88 SOUTH LAKE TAHOE-TAHOE KEYS: Engineering-Science, Inc., Oakland.

A residential development is under construction along several miles of dredged waterways located near the Upper Truckee River on the south end of Lake Tahoe. In the interest of lake water pollution prevention and adequate water quality control within the development's waterways, a research and water quality program is now underway at this development site. The physical, chemical, and biological characteristics of the water and benthos of the

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dredged waters are being established in order to develop an effective economical water quality control program. An extensive water circulation system between the lake and waterways has been planned for the prevention of water stagnation problems within the waterways. The investigation will be continued throughout 1966.

Project Started: Fall 1965 (duration - one year).
Personnel: 1 engineer, 1 chemist, 1 biologist, 1 microbiologist.
Principal Investigator: Ralf C. Carter.

Special Equipment: limnological equipment, scuba equipment, in-situ productivity apparatus, sample concentrating device for 0.005 ppm level of nutrients.

89 IMPROVED WASTE TREATMENT DESIGN OF SUBMARINE DISPOSAL:
Engineering-Science, Inc., Oakland.

Marine waste disposal is becoming of increasing importance in coastal states; however, most coastal treatment plants utilize conventional operations (developed largely for inland disposal to fresh water streams or lakes) and hence are not particularly efficient for marine disposal. Previous studies for Engineering-Science, Inc. indicated that the removal of floatable material should be the controlling factor in disposal to the marine environment. It was the object of the research to develop simplified and/or improved methods for such removal or control, together with development of methods for measuring floatable material in waste effluents and in the marine environment needed for the evaluation of performance of improved treatment methods. The research has yielded the following results:

(1) Development of a liquid-liquid extraction method for determination of hexane extractable material in sewage using direct extraction in a one-liter sampling bottle.
(2) Development of a quantitative method of determining floatable material in sewage using a special Teflon-coated floatation funnel.
(3) Conclusions indicating that promising treatment methods for marine disposal are pressure floatation of raw sewage, improved gravity retention focused on improving floatable solids removal, and gravity retention followed by pressure floatation of the effluent.
(4) Development of a sampling device for quantitative collection of floatable material on the ocean surface.

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Project Started: June 1963 (duration - to January 1967).
Principal Investigator: Harvey F. Ludwig.

Special Equipment: specially designed liquid-liquid extraction apparatus for determination of hexane extractable material in sewage, specially designed and fabricated Teflon-coated funnel for quantitative determination of floatable material in sewage, specially designed and fabricated sampling device for quantitative collection of floatable material on the ocean surface.

Publications: Determination and Removal of Floatable Material from Waste Water. Summary Report Project Years 1963-65, prepared for Division of Water Supply and Pollution Control USPHS by Engineering-Science, Inc., November 1965.

90 IN-SITU INVESTIGATION OF MOVEMENT OF GASES PRODUCED FROM DECOMPOSING REFUSE: Engineering-Science, Inc., Oakland.

In Southern California, since World War II, serious concern has developed among various public and private agencies over possible ground water degradation resulting from the disposal of municipal refuse by landfilling. One of the potential pollutants is carbon dioxide gas which is a product of refuse decomposition. This gas, moving into the soil from the refuse, is of great importance because of its high solubility in water, tending toward a lowering of pH with the likelihood that the water will increase in hardness or other mineralization. This research had as its major aim the determination of the velocity and quantity of movement of refuse gases in the soil surrounding a landfill. A suitable test site was chosen in a section of a gravel pit operated by the Azusa Rock and Sand Co. The test landfill was installed with gas monitoring probes located throughout the refuse and in a pattern of wells surrounding the fill. It was thereby possible to detect gas production within the refuse and in the surrounding soil. Carbon dioxide was found to be the only decomposition gas moving into the soil in any significant amounts. Estimates of the velocity and magnitude of CO_2 movement were made. It was concluded that a landfill can be expected to contribute CO_2 to the surrounding soil for many years and that, if a given ground water is deemed to be in danger from CO_2 pollution, forms of gas control might be needed. Current research is directed toward finding means of preventing or minimizing gas movement into the ground, such as investigation of barrier materials (plastics, etc.), ventilation and burnoff (CH_4, e.g.) and the role of soil cover.

90 (continued)

Project Started: December 1961 (duration - to June 1966).
Personnel: 3 engineers.
Principal Investigator: Harvey F. Ludwig.

Special Equipment: Specially designed and fabricated plastic probes for gas sampling, special temperature and moisture probe for soils, specially designed and fabricated equipment for collecting and measuring rate and amount of carbon dioxide passing upward through fill cover to the atmosphere.

Publications: Bishop, William D., Ralf C. Carter and Harvey F. Ludwig. 1965. Gas movement from landfilled rubbish. Publ. Wks. November 1965.

Bishop, William D., Ralf C. Carter and Harvey F. Ludwig. 1966. Water pollution hazards from refuse-produced carbon dioxide. Paper submitted and accepted for the third conference of the International Association on Water Pollution Research, Munich, Germany.

Two annual reports and six progress reports to the California State Water Quality Control Board.

91 RELATIONSHIP OF TREATMENT METHODS TO SUSPENDED MATTER IN WATER: Engineering-Science, Inc., Oakland.

The objectives of this research were to characterize suspended particulate matter in water, to conduct laboratory investigation involving a variety of water treatment processes, and to develop correlations and conclusions in order to improve the removal of suspended matter. Cation exchange capacity (CEC) of suspended matter in a suspension was measured by a developed method using methylene blue. Average size of suspended matter could be approximated by the ratio of suspension CEC and the weight of suspended matter in unit volume. The jar test with alum indicated that the alum dosage of coagulation is dependent on suspension CEC, At a constant pH of coagulation, the alum dosage decreased with the increase of CEC when suspension CEC is less than about 10 mg/l. When CEC is greater than about 10 mg/l, the alum dosage increased with the increase of CEC. It was also observed that the optimum pH of coagulation was dependent on a suspension alkalinity, and the type of suspended matter. Mobility measurement along with jar test was run to explain the interrelationship of CEC, pH, alkalinity, and the type of suspended matter. The change of particle mobility with the passing of time after the addition of alum was noted and it was explained by CO_2 equilibrium. An attempt was made to measure the filterability of coagulated and settled water, and a modified method of "Silting Index" measurement was found promising.

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Project Started: September 1, 1961 (duration - to February 10, 1965).
Principal Investigator: Harvey F. Ludwig.

Special Equipment: microscopic electrophoresis cell, silting index apparatus.

Publications: Wonsuk, Kim, Harvey F. Ludwig and William D. Bishop. Cation exchange capacity and pH in the coagulation process. J. Am. Wat. Wks. Assn. 27(3):327, March 1965.

Two annual reports (1963-1964, 1964-1965) to USPHS

92 PLANNING AND CONDUCTING A WATER SYSTEM RECOVERY OPERATION IN A POSTATTACK FALLOUT SITUATION: REQUIREMENTS AND PROCEDURES FOR POSTATTACK SANITATION: Engineering-Science, Inc., Arcadia.

A determination of the response of city water distribution systems to nuclear weapons attack, blast vulnerability and fallout radiation, and recovery operating procedures. The development of material for a prototype manual for planning and conducting a water system recovery operation in a postattack fallout situation. A determination of the environmental response to nuclear weapons and postattack sanitation requirements. The removal of fallout material from the recovery environment.

Project Started: September 1964 (duration - three years).
Personnel: 4 engineers.
Principal Investigators: Judson A. Harmon and Harvey F. Ludwig.

Publications: A prototype manual on civil defense aspects of water works operations.

Postattack Sanitation, Waste Disposal, Pest and Vector Control Requirements and Procedures.

93 METHODOLOGY FOR COMPARATIVE ENGINEERING ANALYSIS OF ALTERNATIVE PROCESSES FOR SALINE WATER CONVERSION: Stanford Research Institute, Menlo Park.

Stanford Research Institute, Menlo Park, California has developed a procedure for comparative engineering analysis of saline water conversion processes. A differential-associated cost method was developed that permits comparison of processes on a uniform and objective scale, utilizing a normalized cost procedure. The method consists of three basic steps:

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(1) Estimation of capital and operating costs of a process for a selected set of design specifications, operating conditions, and cost factors.
(2) Grouping of the associated operating costs into components.
(3) Calculation of the differential costs or the change in operating costs resulting from changes in the values of variables from the selected basis.

The resulting rating allows direct comparison of processes, based on their present state of development, and permits an evaluation of the effects of either actual or proposed improvements. By grouping of various costs associated with different components of the processes, the relative importance of each can be directly evaluated, and the limiting steps of a process can be determined objectively. The limiting or critical steps of a process can be analyzed to determine if further significant reduction in cost is attainable, thereby improving the feasibility of the process. If improvements in the critical steps are unlikely to be realized, the potential of the process is limited. The method was utilized to evaluate 13 processes in varying degrees. The results of the Institute's study are presently graphical in many cases.

Project Started: January 1963 (duration - to February 1966).
Principal Investigator: Robert E. DeLaRue.

94 MATHEMATICAL MODEL OF HYDRAULIC AND WATER QUALITY CHARACTERISTICS OF SUISUN BAY AND SAN PABLO BAY: Water Resources Engineers, Inc., under contract to USPHS, Division of Water Supply and Pollution Control.

The project objective is the development of a mathematical model for simulation of hydraulic behavior of a portion of the estuary of the Sacramento-San Joaquin River system. The model, when developed, will be capable of reproducing tidal elevation and current behavior in two-dimensional, vertically mixed estuaries and accepting a previously-developed water quality model of a comparable system.

Project Started: June 21, 1965 (duration - 9 months).
Personnel: 3 engineers.

Special Equipment: IBM 7094 computer and auxiliary equipment.

95 CANNERY WASTE DISPOSAL, TREATMENT AND UTILIZATION: Water Resources Engineers, Inc., under contract to California Water Quality Control Board.

The project is aimed at developing effective systems for treatment, disposal, and/or utilization of liquid and solid wastes from the food canning industry. Studies are being conducted on wastes from peach and tomato canning at Stockton, California. The project is to be conducted in three phases:

(1) Characterization in-plant of waste streams and water use.
(2) Evaluation of waste treatability by physical, chemical, and biological processes.
(3) Pilot-scale evaluation of selected treatment systems with emphasis on economic feasibility as well as industry-wide application.

Project Started: June 1964 (duration - 3 years).
Personnel: 6 engineers, 3 chemists, 1 microbiologist.
Principal Investigator: Gerald T. Orlob.

Publications: Review of Literature - Cannery Waste Treatment, Disposal and Utilization. Report by Water Resources Engineers, Inc. to State Water Quality Control Board, September 1965.

HAWAII

96 GROUND WATER POLLUTION STUDY, KALAUAO, OAHU: Board of Water Supply, C & C of Honolulu.

Determine effect, extent, and rate of ground water, chemical, bacteriological pollution due to return irrigation water, tidal action, sea water encroachment and natural infiltration under a regimen of pumping. Due to changing land uses, the study will be extended to determine the effects of changing land uses on the quality of ground water in the area. This phase of the study will continue on a reduced scale for some years in order to develop the necessary data on the changes.

Project Started: February 1959 (duration - through 1965).
Personnel: 1 engineer, 1 chemist, 1 microbiologist.
Principal Investigator: J. Chang.

Special Equipment: gas chromatograph.

97 SHELLEY LAGOON, SECONDARY WASTE TREATMENT STUDY: The R. T. French Company, Shelley.

Phase 1 - 1963-64 season. A preliminary test was conducted to see if potato waste could be treated in lagoons and in conjunction with sanitary waste.
Phase 2 - 1964-65 season. The indications of the first phase were that potato wastes could be treated by lagoons and in conjunction with sanitary sewage. Phase 2 was to increase the lagoon BOD loading at intervals throughout the year to determine the rate at which the lagoon could be loaded and to check algae and plankton strains being produced. Fish were also added to the lagoon to observe their reactions.
Phase 3 - 1965-66 season. From phase 2 we found that we may be able to load the lagoon at 150 lbs. of BOD/acre/day. This loading is now being maintained throughout the entire year, with the algae and plankton strains still being observed.
Phase 4 - Hopefully we will add aeration to the lagoon and perhaps some design changes. Objectives: (1) Determine highest safe BOD loading in a lagoon. (2) Determine whether potato waste and sanitary waste can be treated together more economically than separately. (3) To find the most efficient lagoon design and use for potato wastes. (4) Determine if there are any profitable byproducts (fish, algae, etc.) that could be harvested from lagoons treating potato wastes.

Project Started: October 1963 (duration - to summer of 1967).
Personnel: 2 chemists, 1 clerk.
Principal Investigators: W. M. Swanson, K. L. Sirrine.

Publications: Two brief reports presented to the Engineering Committee of the Idaho Potato Processors Association.

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MONTANA

98 STREAM SEDIMENT INVESTIGATION: Montana Fish and Game Department, Helena.

Certain agricultural practices are responsible for the addition of gross quantities of sediment into streams. These practices include (1) overgrazing the entire watershed; (2) brush and tree removal on the floodplain and along streambanks; (3) snag removal and channel realignment; (4) row crop production on steep sloping land; (5) overgrazing on floodplain land; and (6) surface irrigtion return water. The purpose of this study has been to obtain information which expresses an inverse relationship between sediment concentrations and trout production. The aim of the project is to specifically locate the source of gross sediment concentrations and then to cooperate with the various governmental agencies concerned with irrigation projects so that corrective measures can be undertaken.

Project Started: 1960 (duration - to 1975).
Personnel: 1 biologist.
Principal Investigator: Don R. Bianchi.

Special Equipment: Mark VI standpipe, Type E water level recorders, P-48 depth integration suspended sediment sampler, Ryan and Taylor thermographs.

Publications: Bianchi, D. R. 1963. Stream sediment investigation, Job Comp. Rep., F-20-R-8. Montana Fish and Game Department.

Bianchi, D. R. 1964. Stream sediment investigation. Job. Comp. Rep., F-20-R-9. Montana Fish and Game Department.

Bianchi, D. R. Effects of sediment on egg survival of rainbow trout and cutthroat trout. (Unpublished).

Peters, J. C. The effects of stream sedimentation on trout embryo survival. Biological Problems in Water Pollution, 3rd Seminar, USDHEW PHS No. 999-WP-25. pp 275-279.

Peters, J. C. 1963. Stream sedimentation and trout populations in Bluewater Creek, Montana. (Unpublished).

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99 DETECTION AND SIGNIFICANCE OF ENZOOTIC WATER POLLUTION: University of Montana, Missoula.

The purpose of this investigation is to determine the qualitative and quantitative aspects of wild animal and bird pollution on water, including surface and underground. The health aspects of the pollution will also be examined.

Project Started: September 1, 1965 (duration - 4 years).
Personnel: 2 biologists, 2 microbiologists.
Principal Investigators: Mitsuru Nakamura and William B. Rowan.

100 INDUSTRIAL ORGANIC MICROPOLLUTANTS AND PROTOZOA: University of Montana, Missoula.

Water pollution and water quality studies in this country, with a few notable exceptions, while stressing the larger invertebrates and vertebrate members of food chains such as the aquatic insects and fish, have neglected the smaller protozoa. Yet these animals, besides being often primary consumers, display several features that make them compelling study material for water research. The primary purpose of this study is to determine the usefulness of free-living protozoa as bioassay tools in the study of organic micropollution. We will attempt to screen as broad a range of protozoa as possible within the time period available. Special attention will be given, however, to ciliates such as Tetrahymena pyriformis and Paramecium spp. that can be maintained in axenic culture on defined medium. Most of the measurements to be made will relate to the impact of the pollutant on the population growth curves of the cultures. Secondarily, the study should contribute to an understanding of the ecology of protozoan populations.

Project Started: Juanuary 1, 1966 (duration - 1½ years).
Personnel: 2 biologists.
Principal Investigator: W. B. Rowan.

101 THE ROLE OF FRESH WATER SNAILS IN THE EPIDEMIOLOGY OF SALMONELLAE: University of Montana, Missoula.

The purpose of this study is to determine the extent to which snails of the general Lymnaea, Helisoma, and Physa are capable of harboring economically important pathogens such as Salmonella typhi-murium (livestock), S. pullorum (poultry) and related forms. The snails are exposed to the bacteria, maintained for varying periods of time, surface sterilized,

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and their tissues sectioned and cultured. The study is expected to contribute knowledge to the epizootiology of Salmonella, and is preliminary to more extensive work in this area.

Project Started: November 1, 1965 (duration - 2 years).
Personnel: 2 biologists.
Principal Investigators: M. J. Nakamura, W. B. Rowan.

OREGON

102 THE INFLUENCE OF LOGGING ON THE SURVIVAL TO EMERGENCE OF COHO SALMON AND STEELHEAD: Oregon Game Commission, Research Division, Portland.

The objectives of this study are to:

(1) Determine the influence of the intragravel environment on survival (to emergence) of salmonids.
(2) Develop methods of measuring directly that survival.
(3) Measure the impact of logging on the intragravel environment.

Project Started: 1960 (duration - to 1973).
Personnel: 3 biologist, 1 graduate assistant.
Principal Investigators: R. W. Phillips, H. J. Campbell.

Publications: Koski, K. Victor. 1966. The survival of coho salmon (*Oncorhynchus kisutch*) from egg deposition to emergence in three Oregon coastal streams. M.S. thesis, Oregon State University.

Lowry, Gerald R. 1965. Movement of cutthroat trout, *Salmo clarki clarki* (Richardson) in three Oregon coastal streams. Trans. Am. Fish. Soc. 94:334-338.

Phillips, Robert W. 1961. Alsea watershed study. Misc. paper no. 110, Agri. Exp. Sta., Oregon State University, Corvallis. pp 33-37.

Phillips, Robert W. 1964. The influence of gravel size on survival to emergence of coho and steelhead. 15th Northwest Fish Culture Conference. Corvallis, Oregon.

Phillips, Robert W. and Homer J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. 14th Annual Report of the Pacific Marine Fish Commission. Portland, Oregon. pp 60-74.

103 IMPROVEMENT OF LOGGING METHODS AND MANAGEMENT OF CUTOVER AND BURNED LANDS TO MAINTAIN SOIL STABILITY AND REGULATE RUNOFF IN DOUGLAS FIR AND MIXED CONIFER WATERSHEDS: Pacific Northwest Forest and Range Experiment Station, Corvallis.

To determine the characteristics and interrelations of soil, plants and water, to determine how logging methods, road construction and timber management practices can be improved to curtail erosion and sedimentation, to prevent stream channel impairment,

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and to regulate quantity and timing of runoff in Douglas fir and mixed-conifer forest lands of western Washington and Oregon. Work is in four categories: erosion on logging roads and logged areas, water quality, quantity and timing of runoff, and water use and disposition.

Project Started: 1952 (duration - continuing).
Personnel: 2 forest hydrologists, 2 soil scientists.
Principal Investigator: Jack Rothacher.

Publications: Fredricksen, R. L. 1965. Christmas storm damage on the H. J. Andrews Experimental Forest. Pacific Northwest Forest and Range Experiment Station Res. Note PNW-29, August 1965, 11 p., illus.

Fredricksen, R. L. 1962. Sedimentation following logging road construction in a small western Oregon watershed. Proc. Federal Interagency Sedimentation Conference, Jackson, Mississippi.

104 DISPOSITION OF PESTICIDES IN SOIL AND WATER OF FOREST AND RELATED RANGE ENVIRONMENTS: U. S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Corvallis.

To determine how chemical, physical, and microbiological properties of forest soil are affected by, and lead to alteration and degradation of, chemical pesticide residues; how such residues are moved over and through the soil; how much and in what forms residues are present in waters of forested or related rangeland areas, and to provide information which will serve as a sound basis for devising new or modifying present practices of pesticide use to reduce or eliminate pollution of water by chemical residues.

Project Started: October 1964 (duration - continuing).
Personnel: 1 chemist, 1 microbiologist, 2 soil scientists.
Principal Investigator: Robert F. Tarrant.

Special Equipment: gas chromatograph with electron capture and microcoulometric detection features.

105 WASHINGTON STATE ENFORCEMENT PROJECT: Federal Water Pollution Control Administration, Portland.

The purpose of this project is to determine the effects of pulp and paper mill waste discharges on the water quality and marine resources of Puget Sound. A program composited of engineering, oceanographic, biological, and economic studies has been completed in areas adjacent to Anacortes and Port Angeles, and is nearing its conclusion at Bellingham and Everett. The engineering studies, concluded in

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each area, provide a complete description of the amount and nature of the pulp and paper mill wastes discharged into various sections of Puget Sound. The oceanographic studies, also completed, have (a) determined the dispersion, travel, and persistence of mill wastes in the receiving waters; (b) described the currents and water movements which affect waste dispersion; (c) described the water quality as influenced by mill wastes; and (d) measured the areal coverage, depths, and composition of sludge deposits. The economic studies have delineated some of the important economic factors and established a basis for the judgment of what constitutes reasonable abatement procedures.

There are eleven biological studies which can be categorized into physiology, ecology, and fisheries. The physiological work is composed of long and short term bioassays conducted in situ, in the laboratory using environmental waters, and in the laboratory using prepared, known materials. The test organisms are juvenile salmon, adult oysters, oyster larvae, and English sole eggs. Results indicate that sulfite waste liquor is a severely toxic material, even when quite dilute.

The ecological work is concerned with the composition, distribution, abundance, and relationships of the plankton and benthos in the test areas. Volunteer periphyton communities (on glass slides) and plankton productivity characteristics are also being studied. All data from these investigations are being computer-processed to elucidate significant relationships.

The fisheries studies have demonstrated the distribution and migration patterns of juvenile salmon, the composition and distribution of demersal fishes, and are now concerned with the distribution and abundance of flatfish afflicted with tumors. Preliminary evaluations indicate that juvenile salmon try to utilize receiving waters shown to be toxic and that fish with tumors are found only in shallow waters close to fresh water sources or in polluted areas.

Project Started: January 1962 (duration - to July 1967).
Principal Investigator: E. N. Kari.

Special Equipment: survey vessel equipped with laboratory, hydrographic winches, live tank, and trawling gear.

106 TEST DEVICE FOR COLLECTING MARINE INVERTEBRATES: Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory, Newport.

Six rectangular, compartmentalized plexiglass devices for supporting various substrates were placed in Yaquina Bay, Oregon in 1965 to secure information on kinds and development characteristics of

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invertebrates utilizing the substrates. Findings are to be used in designing a sampler to collect invertebrates of specific interest and in testing the field utility of this approach to systems analysis relative to predicting certain waste load capacities and effects in estuaries. The project entailed the use of four types of replicated substrate plates (roughened and smooth glass, marine plywood, and masonite) and two types of duplicated substrate boxes (rocks and shells, and sediment) set at two depths during two seasonal periods over varying periods of time (3, 6, and 9 weeks).

Project Started: June 30, 1965 (duration - to June 30, 1966).
Personnel: 1 biologist.
Principal Investigator: William D. Clothier.

107 ANNOTATED BIBLIOGRAPHY OF COASTAL AND ESTUARINE WATERS OF OREGON AND WASHINGTON: Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory, Newport.

A review of literature for an annotated bibliography of pertinent research papers on biological, chemical, geological, and physical characteristics of the marine and tidal waters and adjoining shore areas in Oregon was initiated in 1965 to facilitate research planning and program development relative to waste disposal problems in salt water. Four bibliographies are to be prepared, each to cover subject matter in the following geographical areas:

(1) Coastal and estuarine waters of Oregon.
(2) Outer coastal and estuarine waters of Washington.
(3) Puget Sound.
(4) Columbia River and its discharge area.

The latter two will be updated supplements to bibliographies published by the University of Washington. A first draft of the first compilation, "A contribution to a bibliography of Oregon coastal and estuarine waters", has been readied for editorial review. It contains about 400 annotated references.

Project Started: January 1965 (duration - June 1968).
Personnel: 1 oceanographer.
Principal Investigator: George Ditsworth.

108 EFFECTS OF WATERSHED ACTIVITIES ON WATER QUALITY IN THE PACIFIC NORTHWEST: Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory, Corvallis.

Overall objectives:

(1) To determine the impact and effects of current and proposed watershed uses and practices on water quality in the Pacific Northwest.
(2) To determine the nature and causes of water quality problems in Pacific Northwest watersheds.
(3) To develop measures for prevention and correction of water quality problems that arise from the region's watershed practices.

Project Started: January 1, 1964 (duration - to 1971).
Personnel: 1 forester, 1 technician.
Principal Investigator: Richard B. Marston.

Special Equipment: electrolytic conductivity recorders.

109 EFFECTS OF MULTIPLE-PURPOSE IMPOUNDMENTS ON WATER QUALITY: Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory, Corvallis.

A study of water quality in impoundments, current and stratification patterns, the biota, and interrelationships of the chemical, biological, and physical parameters. The objective is to develop sufficient basic information on the ecological, chemical, and physical effects and changes occurring in the impoundments to permit forecasting future water quality and to safeguard the quality of the water passing through them.

Project Started: November 1964 (duration - long term).
Personnel: 1 engineer, 1 technician, (current year).
Principal Investigator: Lyman J. Nielson.

110 TREATMENT PROCESSES: Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory, Corvallis.

Immediate objectives are:

(1) To develop methods for assessing nature and extent of water quality degradation caused by pulp and paper wastes.
(2) To assimilate information and evaluate remedial processes now available.
(3) To field test potentially applicable processes in cooperation with industry and others.

110 (continued)

Specific projects presently proposed are as follows:

(1) Develop a more significant and useful test as a substitute for the Pearl-Benson index to differentiate sulfite waste liquor from other reactive compounds in waste waters and natural waters.
(2) Document all known and available methods and means for the utilization, recycle, recovery and treatment of wastes from the pulp and paper industries. A publication will ultimately be developed.
(3) Determine the use of such treatment processes of mills within the Pacific Northwest. Pilot scale operations will be developed in cooperation with the pulp and paper industries.
(4) Determination of the effects of log storage on water quality.
(5) Coordinate a national program relating to waste water research in the pulp and paper industry.

Project Started: July 1965 (duration - continuing).
Personnel: 1 engineer, 2 chemists.
Principal Investigator: Ralph Scott.

111 EUTROPHICATION: Federal Water Pollution Control Administration, Pacific Northwest Water Laboratory, Corvallis.

This project is studying the sources of plant nutrients in water bodies and their effects on water use. Nutrients stimulate intensive and extensive growths of water plants which, when they die and decay, cause secondary oxygen-demanding pollution in the receiving waters, accompanied by disagreeable tastes and odors. The problem of nutrient accumulation in water bodies is widespread in the nation. This project is limited to the Upper Klamath Lake in Oregon. Four objectives are as follows: assemble information available from past studies on Upper Klamath Lake, determine where algal nutrients are obtained from within the watershed, learn more about the physiological characteristics of the nuisance blue-green algae in the lake, and find some feasible method of controlling algal production in Upper Klamath Lake.

Project Started: September 1964 (duration - to September 1967).
Personnel: 3 chemists, 3 biologists, 1 technician, 1 clerk-stenographer, 1 consultant.
Principal Investigator: Leslie Seyb.

112 UNDERGROUND WATER OF THE DESCHUTES RIVER BASIN: Central Oregon College, Bend.

Project Objectives:

(1) Field study and compilation of water wells in the Deschutes Basin.
(2) Thin section study of related formations.
(3) Mapping of structure from well logs.
(4) Determination of static water table.

Project Started: 1959 (duration - to 1967).
Personnel: 1 engineer, 2 assistants.
Principal Investigator: William W. Hudson.

113 EFFECTS OF CHEMICAL AND BIOLOGICALLY MODIFIED PULPING EFFLUENTS ON THE PRODUCTION OF FISH: National Council for Stream Improvement, Corvallis.

Objectives: To determine whether various chemical and biological modifications of pulp mill effluent are effective in reducing effluent toxicity to finned fish. The effect of biological modification of kraft effluents in short term acute toxicity has been initiated. This work will be continued and expanded to include detailed characterization of other effluents and assessment of biological and chemical modification on short term acute toxicity and productivity of finned fish.

Project Started: 1965 (duration - 4 years).
Personnel: 2 engineers, 1 biologist.
Principal Investigators: R. O. Blosser and E. L. Owens.

114 A STUDY OF TEMPERATURE MICROSTRUCTURE AT THE OCEAN FLOOR AND ITS IMPLICATIONS WITH REGARD TO HEAT FLOW OBSERVATIONS: Department of Oceanography, Oregon State University, Corvallis.

The objective of this project is to initiate a study of the stability of the temperature environment at the deep ocean floor. A new thermal probe for measuring long time variations in temperature at the sea bottom interface of the ocean floor is being constructed. Thermal measurements will be made to a depth of several meters in the sea bottom and to a height of 1 or 2 meters above the floor of the ocean. The initial design of the instrument is nearly complete. Recovery techniques are now being investigated. Theoretical studies concerning temperature fluctuations at bottom of the ocean are being conducted, in relation to eddy or turbulent diffusivity.

114 (continued)

Project Started: June 1965 (duration - to May 1966).
Personnel: 1 oceanographer, 1 geophysicist, 2 students.
Principal Investigator: G. Bodvarsson.

Special Equipment: temperature probes for deep-sea use and oceanographic vessel, YAQUI A.

115 THE PREDICTION OF UNSATURATED FLOW RATES FROM PHYSICAL PROPERTIES OF THE POROUS MEDIUM: Oregon State University in cooperation with Water Resources Research Institute, Department of the Interior, Corvallis.

Objectives:

(1) To establish a relationship between water transmission coefficients of a porous medium and the physical properties of the medium by a series of systematic measurements.
(2) To develop a method by which water transmission coefficients for any porous material may be predicted reliably by means of an analytic procedure.
(3) To establish the possible use of a mercury intrusion porosimeter as a tool for the routine measurement of pore size distribution.
(4) To compare values of water transmission coefficients calculated from pore size distributions with experimentally obtained values.

The development of the unsaturated flow theory leads to the determination of several parameters necessary for the prediction of water movement in porous media. Little investigation has been done to determine these parameters as a function of easily measured physical properties of the medium. The flow parameters have been related to characteristic functions obtained from experiments. The theory has been successful in some cases under special conditions. When experimental data do not match with the values predicted using the characteristic functions, only assumptions about the discrepancies between theory and experience can be presented. The objective of the proposed study is to establish a relationship between water transmission coefficients and properties of the porous medium by a series of systematic measurements performed on a range of materials. The need for fundamental information about unsaturated flow parameters obtained in a systematic manner is urgent. Unsaturated water movement is a basic aspect of many studies related to water treatment, movement of chemicals (pesticides) and movement of water as part of the hydrologic cycle.

Project Started: January 1, 1966 (duration - 3 years).
Personnel: 4 soil scientists.
Principal Investigator: L. L. Boersma.

116 INVESTIGATION OF AQUATIC WEED PROBLEMS AND MEANS OF CONTROL WITH EMPHASIS ON BRAZILIAN WATERWEED: Oregon State University, Corvallis.

Objectives:

(1) To determine means of controlling Brazilian waterweed and other nuisance aquatic plants.
(2) To assess impact of control measures on recreational, industrial, and domestic uses of the bodies of water involved.
(3) To determine effect of aquatic herbicides on pond invertebrates.

Preliminary screening tests have been carried out to determine the effectiveness of a number of chemicals against Brazilian waterweed, and secondary tests using some of the more effective have been run at several concentrations. Cultures of aquatic invertebrates are being started.

Project Started: July 1, 1965 (duration - indefinite).
Personnel: 2 biologists, 1 aide.
Principal Investigator: C. E. Bond.

Special Equipment: covering bottom with polyethylene plastic, using chemicals to kill plants.

Publications: Progress report on weed control project, Oregon State University, Agricultural Experiment Station, February 1966.

117 RELATIONS OF NUISANCE ALGAE TO FISHES IN KLAMATH LAKE: Oregon State University, Corvallis.

The overall objective is to determine ecological and other effects of nuisance blue-green algae on fishes in Klamath Lake and other bodies of water which might be enriched by Klamath Lake water. Specifically, the aims of the research are:

(1) Determine the seasonal and spatial distribution of fish species in relation to algae concentrations. Attention will be given to species representing several ecological functions (scavengers, insectivores, carnivores, etc.).
(2) Determine the reasons for any differential distribution of fish involving blue-green algae, with attention to limnological parammeters and observed toxic effects.
(3) Determine possible direct toxic effects of algae and algae extracts on fish by bioassays in the field and laboratory.
(4) Investigate the extent to which invertebrates important in the food chains of fishes are affected directly by algae blooms.

Project Started: June 1, 1964 (duration - 3 years).
Personnel: 3 biologists, 2 aides.
Principal Investigator: Carl E. Bond.

Publications: Progress report to USPHS.

118 PULP MILL WASTE DEGRADATION IN MARINE WATER: Oregon State University, Corvallis.

The project is an interdisciplinary effort by engineers and biologists on the treatment of pulp mill wastes. Biological research includes development of bioassays involving the embryo of the bay mussel (*Mytilus edulis*), the Pacific oyster (*Carassostres gigas*), and exploration of the use of the marine algae (*Monochrysis sp.*). The embryo tests are based upon the survival and growth of the embryo and the abnormal development of embryo exposed to different wastes from the kraft mill process of pulp production. The bioassay techniques developed are used to evaluate efficiency of treatment methods investigated in the engineering research. Engineering investigations are concentrated on treatment of kraft mill waste streams by lagoon storage of whole mill waste, carbon adsorption treatment of digester condensates, foam fractionation of whole and strong mill wastes (excluding white water), and activated sludge treatment of whole mill waste. Through this joint effort it is hoped to gain a better understanding of the biological impact that treated wastes have on marine waters and to determine the potential of the above treatment processes.

Project Started: April 1, 1964 (duration - to March 30, 1967).
Personnel: 3 engineers, 2 biologists.
Principal Investigator: Fred J. Burgess.

Publications: Dimick, R. E. 1964. Use of the bay mussel *Mytilus edilus* to evaluate toxicity of kraft mill wastes. Industrial Waste Conference, University of Washington (In press).

Hansen, S. P. Application of activated carbon to the treatment of kraft mill evaporation condensate wastes. M.S. Thesis. (In press - to be completed January 1966).

Blazier, J. L. 1965. Foam separation of organic and toxic materials from kraft mill wastes. M.S. Thesis.

119 WATER REUSE - QUANTITY - QUALITY EFFECT ON TREATMENT PROCESS: Oregon State University, Corvallis.

The objective of this demonstration project is to evaluate the quantity and quality variations in waste flows upon the effluent quality in a tertiary treatment system involving coagulation, filtration and carbon adsorption combination of units. A second objective is to conduct applied research on removal of color from combined domestic and beet cannery waste. Research demonstrations and applied investigations will be conducted in a Research Demonstration Laboratory being constructed adjacent to the Corvallis, Oregon sewage treatment plant. This facility will accommodate this demonstration project and will be a permanent facility for evaluating pilot plant and proprietary device performance.

119 (continued)

Project Started: June 1965 (duration - to April 1968).
Personnel: 1 engineer.
Principal Investigator: Fred J. Burgess.

Special Equipment: laboratory designed to provide continuous samples of raw, settled, filter effluent and adjacent treatment plants to laboratory for use in pilot plant work.

120 AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL: Department of Agricultural Economics, Oregon State University, Corvallis.

Objectives:

(1) Identify the items of economic value that will be sacrificed if pollution is not controlled in a particular case study situation.
(2) Insofar as possible, determine the unit prices and physical quantities of those items of economic value identified in (1).
(3) Determine the cost of alternative engineering plans designed to provide for varying degrees of pollution control.
(4) Relate the above variables in a mathematical model that will permit the unknown physical, biological and economic data to be isolated.
(5) Relate the unknown variables in (4) above to needed research in the physical, biological and economic fields.

Project Started: September 1, 1962 (duration - 4 years).
Personnel: 1 economist.
Principal Investigator: E. N. Castle.

Publications: Castle, E. N. 1965. The market mechanism, expernalities, and land economics. J. Fm. Econ. 47(3):542-556.

Stevens, Joe B. 1965. Angling success as a quality determinant of sport fishery recreational values: an empirical analysis. Proceedings, Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, San Francisco, California, December 1965.

Stoevener, H. H. 1963. An economic evaluation of water pollution control alternatives: a progress report. Conference Proceedings, Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Report No. 12, Salt Lake City, Utah, December 1963. pp. 1572-1579.

Stoevener, H. H. 1964. Water use relationships as affected by water quality on the Yaquina Bay. New Horizons for Resources Research: Issues and Methodology, Western Resources Conference, University of Colorado, Boulder. pp. 87-99.

120 (continued)

Stoevener, H. H. and E. N. Castle. 1965. Input-output models and benefit-cost analysis in water resources research. *J. Fm. Econ.* 47(5):1572-1579.

121 ESTUARINE WATER QUALITY: Department of Oceanography, Oregon State University, Corvallis.

Research into chemical, biological, geological and physical effects of pollution on estuarine water quality. Specific efforts will be put forth in the Columbia River estuary, Alsea estuary, Yaquina Bay, Tillamook Bay, etc.

Project Started: July 1966 (duration - 1 year).
Personnel: 4 chemists, 5 biologists.
Principal Investigator: Herbert Curl, Jr.

Special Equipment: nitrogen and carbon analytical equipment, gas chromatograph.

122 TOXICOLOGY OF PESTICIDES IN THE ENVIRONMENT: Oregon State University, Corvallis.

The project is divided into a number of programs which are cooperative in that the same chemicals are being used in related studies in order that an understanding of the behavior of the chemicals can be developed, particularly as related to environmental health. The different programs currently underway as part of the total project include:

(1) Studies of pesticides in simple food chains using laboratory streams in which animal communities have been established and into which pesticides in solution can be introduced. A separate but related effort involves determining the ecological conditions of a natural stream before and after the use of DDT on the watershed for tussock moth control.
(2) Studies on the influence of pesticides on blood pressure or heart contractile force, and other toxic stresses.
(3) Investigation and pathology of long-term feeding of a sublethal dose of selected pesticides and herbicides to laboratory animals under controlled environmental conditions.
(4) Determining the effects of pesticides on isolated enzyme systems.
(5) Analytical chemistry of pesticides such as analyzing water and determining pesticide levels resulting from long-term orchard treatment including the degree to which surface and ground water has been contaminated, studying pesticide levels in lakes which have been chemically treated to eliminate trash fish.

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(6) Studying the relationship between pesticide toxicity and nutritional variables.
(7) Determining the effects of pesticides on metabolism in mammals.
(8) Studying the metabolic breakdown of pesticides in plants.
(9) Evaluation of an organic-phosphorus parasiticide especially in regard to parasite-host metabolism.
(10) Investigation of the effect on behavior and longevity of organisms receiving chronic exposure to low levels of pesticides, with emphasis on the honey bee.
(11) Studying soil-pesticide interactions such as developing adsorption isotherms, determining the extent to which pesticides are adsorbed by organic matter in the soil, and stimulating pesticide movement in the soil.
(12) Studying the effect of pesticide ingestion on metabolism resulting from subcellular fractions.

Project Started. June 1964 (duration - continuing).
Principal Investigator: V. H. Freed.

Publications. Frady, C. H. and S. E. Knapp. 1965. Source of acetylcholinesterase in Fasciola hepatica. J. Parasit. (In press).

Freed, V. H. 1965. Chemistry of Herbicides. Am. Soc. Agron. meeting in Columbus, Ohio 11/3/65. (In press).

Helfer, D. H. and S. E. Knapp. 1965. Meriones unguiculatus - a new experimental host for Fasciola hepatica. J. Parasit. (In press).

Philleo, William W. 1965. The effect of 2,4-dichlorophenoxyacetic acid on the in vivo metabolism of acetate in rats. M.S. Thesis.

Tinsley, Ian J. 1965. DDT ingestion and liver glucose 6-pyosphate dehydrogenase activity II. Biochem. Pharmacol. 14:847.

Tinsley, Ian J. 1965. Nutritional interactions in dieldrin toxicity. Paper presented at the American Chemical Society meeting in January 1966.

123 BIOCHEMISTRY AND PHYSIOLOGICAL ECOLOGY OF POISONED FISH: Department of Agricultural Chemistry, Oregon State University, Corvallis.

Objectives.

(1) To determine the effect of selected toxic substances on enzymes of nerves, muscles and digestion.

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(2) To determine the influence of these effects on performance, behavior, growth and production.

Continuing work has been underway to determine the biological and biochemical effects of various toxicants, such as pentachlorophenol, on fish. These are being related to survival and performance of fish and are being used to evaluate toxic hazards in the environment. The adaptation of fish biochemical systems to toxicant exposure is also being studied.

Project Started: March 1962 (duration - to February 1967).
Personnel: 5 chemists.
Principal Investigator: V. H. Freed.

Special Equipment: gas chromatography 2-types electron capture, Dorhamn Thin-Layer, Beckman Spectrophotometer Belfort attachment, refrigerated centrifuge.

Publications. Lu, S. D. and V. H. Freed. Effect of pentachlorophenol on ATP levels and oxidative phosphorylation in cichlids.

Chang, J. T., V. H. Freed, and S. D. Lu. Effect of pentachlorophenol on selected enzymes in cichlids and goldfish. Based on thesis of senior author - The effect of potassium pentachlorophenate on selected enzymes in fish.

124 CHEMICAL BRUSH CONTROL: BIOCHEMISTRY AND TOXIC HAZARD: Department of Agricultural Chemistry, Oregon State University, Corvallis.

This study concerns the use of herbicides on forest land for brush control and the environmental contamination which results. The purpose is to determine the impact of chemical brush control operations as they are practiced today on environmental contamination with special emphasis on stream contamination. The goal of this program is to provide the land manager with the quantitative data necessary to permit the evaluation of specific chemical brush control programs in terms of possible environmental contamination and to provide a scientific basis for the formulation of sound forest spray policies.

Included in this project are intensive stream sampling programs in connection with operational chemical brush control projects on forest lands. Other studies are concerned with determinations of the rates and pathways of herbicide degradation in several portions of the forest environment including soil, forest floor litter, water, and vegetation. Studies of the biochemistry and physiology of action of brush control chemicals in woody plants are also being conducted as a means of gaining a better understanding of their behavior in the field. These studies of herbicide action are intended to provide information which will result in the more efficient use of herbicides and reduced levels of contamination from their use through the application of less chemical or the use of less persistent chemicals to accomplish the same vegetation manipulation objectives.

Project Started: June 1, 1963 (duration - 5 years).
Personnel: 1 chemist, 2 biologists, 1 technician.
Principal Investigator: V. H. Freed.

Special Equipment: 2 growth chambers, several gas chromatographs, assorted radiation detection equipment for studies involving radioactive chemicals.

Publications: A study of stream contamination resulting from chemical brush control projects on forest lands of the lower Alsea River basin, 1964. (Unpublished report available to professional personnel on request).

A study of stream contamination resulting from chemical brush control operations on forest lands in Oregon. 1965. (Unpublished report available to professional personnel on request).

Norris, Logan A. Degradation of 2,4-D and 2,4,5-T in forest floor litter. J. For. (In press).

Several other publications are in press which are concerned with the physiological and biochemical aspects of herbicide action in woody plants.

125 ROLE OF MACROFAUNA IN WASTE STABILIZATION LAGOONS: Oregon State University, Corvallis.

Project Objectives:

(1) To determine the species distribution and abundance of insects and other macrofauna in waste stabilization lagoons of various designs in Oregon.
(2) To measure the contribution of the macrofauna in the breakdown of organic wastes and to understand the pathways through which this is effected.
(3) To assess the beneficial and detrimental results caused by the macrofauna in lagoons of various designs.

Though a large number of species are transient residents of the lagoon community, only a few Diptera occur as breeding populations in large numbers. Under shock loading conditions, breeding populations of insects were largely eliminated. Immediately thereafter, pest mosquitos (primarily Culex tarsalis) colonized the lagoons. Absence of mosquite production prior to shock loading suggests that certain management procedures may eliminate mosquito production.

125 (continued)

Project Started: June 1964 (duration - to December 1968).
Personnel: 4 biologists.
Principal Investigator: R. L. Goulding.

Publications: Sturgess, B. T. 1964. The ecology of insects associated with waste water lagoons. M.S. Thesis, Oregon State University. 58 pp.

126 EFFECTS OF WATERSHED PRACTICES ON WATER QUALITY, QUANTITY, AND BIOTIC RESOURCES IN COASTAL STREAMS: Oregon State University, Corvallis in cooperation with Oregon State Game Commission, U. S. Geological Survey, U. S. Forest Service, and Pacific Northwest Water Laboratory of the Federal Water Pollution Control Administration.

Project Objectives:

To determine the effect of two types of logging (clear-cutting and staggering settings) on the physical and biotic resources of small coastal watersheds. Principal resources under study are stream flow and temperature, suspended sediment, chemical water quality, algae, aquatic insects, and fish populations. The pre-logging calibration has been completed and timber access roads have been constructed. Fish traps are installed along with instruments to measure rainfall, streamflow, chemical water quality, suspended sediment, and stream temperature. An energy study is underway to evaluate the temperature regime of the streams, including changes following logging. Several methods of measuring sediment production from logging roads will be evaluated. Preliminary work, including the initial development of an algal respirometer, has been completed in regard to developing an estimate of the annual production of algae. Significant work has been conducted on the survival of coho salmon from egg deposition to emergence, and monitoring of juvenile coho in the streams is being carried out. Since sculpin appear to be a significant predator on coho, a study has been initiated to define the role of the sculpin in the ecology of the streams.

Project Started: 1958 (duration - to 1972).
Personnel: 2 engineers, 5 biologists.
Principal Investigator: J. D. Hall.

Publications: Chapman, Donald Wallace. 1961. Factors determining production of coho salmon, Oncorhynchus kisutch, in three Oregon streams. Ph.D. Thesis. Oregon State University. 214 pp.

Chapman, Donald W. 1962. Aggressive behavior in juvenile coho salmon as a cause of emigration. J. Fish. Res. Bd. Can. 19(6):1047-1080.

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Chapman, Donald Wallace. 1962. Effects of logging upon fish resources of the West Coast. J. For. 60(8):533-537.

Chapman, Donald W. 1965. Net production of juvenile coho salmon in three Oregon streams. Trans. Am. Fish. Soc. 94(1):40-52.

Chapman, Donald W., John F. Corliss. Robert W. Phillips and Robert L. Demory. 1961. Alsea Watershed study, summary report, Misc. paper 110, Agricultural Experiment Station, Oregon State University. 52 pp.

Chapman, Donald W. and Robert Demory. 1963. Seasonal changes in the food ingested by aquatic insect larvae and nymphs in two Oregon streams. Ecology 44(1):140-146.

Demory, Robert LeRoy. 1961. Foods of juvenile coho salmon and two insect groups in the coho diet in three tributaries of the Alsea River, Oregon. M.S. Thesis. Oregon State University. 68 pp.

Koski, K. Victor. 1965. The survival of coho salmon from egg deposition to emergence in three Oregon coastal streams. M.S. Thesis, 84 pp.

Lane, Charles B. 1965. Metabolism of periphyton communities in two small streams. M.S. Thesis, Oregon State University. 57 pp.

Lowry, G. R. 1964. Some ways of increasing the utility of a packback fish shocker. Progve. Fish Cult. 26:127-130.

Lowry, G. R. 1965. Movement of cutthroat trout in three Oregon coastal streams. Trans Am. Fish. Soc. 94(1):334-338.

Lowry, G. R. Net production and food of cutthroat trout in three Oregon coastal streams. J. Wildl. Mgmt. (In press).

Phillips, R. W. A trap for capturing salmonids emerging from spawn-gravel. Progve. Fish Cult. (In press).

Phillips, R. W. and E. W. Claire. Intragravel movement of the reticulate sculpin and its potential as a predator on salmonid eggs. Trans. Am. Fish. Soc. (In press).

Williams, R. C. 1964. Sedimentation in three small forested drainage basins in the Alsea River basin, Oregon. U. S. Geological Survey Circular 490.

127 EFFECTS OF SELECTIVE LOGGING ON A TROUT POPULATION: Oregon State University, Department of Fisheries and Wildlife, Corvallis.

Project Objectives:

To determine the effects of selective logging in ponderosa pine on a stream trout population and its physical and biotic environment. Emphasis will be placed on changes in population size and growth rate of the trout in evaluation of effects.

A pre-logging inventory of fish population and the physical and biotic characteristics of the two streams being studied is underway. Stations have been installed for the purpose of measuring rainfall, air and water temperature, streamflow, and chemical water quality. Samples of bottom fauna and the drift of insects have been taken several times to provide a measure of food available to the trout. Over 500 trout have been captured and marked to provide a measure of population and growth rates, and a creel census taken to give an estimate of fishing pressure and catch.

Project Started: 1965 (duration - 1971).
Personnel: 2 biologists.
Principal Investigator: J. D. Hall.

128 SIMULATION AS A MEANS OF STUDYING RESOURCE ALLOCATIONS: Oregon State University, Department of Agricultural Economics, Corvallis.

Project Objectives:

(1) To build mathematical models of the environment and decision-making processes of various resource allocating units (firm, industry, agency, both public and private).
(2) To operate and test these models on digital computers.
(3) To design and test alternative decision-making criteria and processes.

A computer simulation model of a relatively small river basin has been developed that is capable of comparing sizes of reservoirs, channel capacities, water use priorities, operating procedures, and other management policies that come within the economic framework.

Project Started: January 1965 (duration - to January 1970).
Personnel: 2 economists.
Principal Investigator: A. N. Halter.

Publications: Halter, A. N. 1965. Simulation models in decision making. Western Range Committee Proceedings, July 1965.

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Halter, A. N. and Gerald Dean. 1965. Simulation as a means of evaluating management policies of a large scale ranch in an environment of uncertainty. J. Fm. Econ. August 1965.

Halter, A. N. and Gerald Dean. 1965. Simulation of a California range-feedlot operation. Giannini Foundation Research, Report No. 282, University of California, May 1965.

Halter, A. N. and S. F. Miller. 1965. Simulation techniques and their application to economic research. Paper presented to Northwest Study Group, Moscow, and the North Central Farm Management Research Committee, October 1965.

Halter, A. N. and S. F. Miller. River basin planning: a simulation approach. Oregon Agricultural Experiment Station Technical Bulletin.

129 TECHNIQUES OF MEASURING EROSION FROM NEWLY-CONSTRUCTED LOGGING ROADS: Oregon State University, School of Forestry, Corvallis.

Project Objectives:

(1) To determine if four techniques of measuring erosion yield essentially the same results, or if the relative precision of these techniques changes with variations in site conditions.
(2) To determine the advantages and disadvantages of each technique.
(3) To obtain point samples of erosion from a newly-constructed logging road in the Deer Creek Experimental Watershed of the Alsea Basin.

Runoff plots have been established on both cut and fill slopes and bi-weekly measurements of erosion are being made using four independent methods: erosion gage, macro-profile, spike and washer, and catchment-filter.

Project Started: April 1965 (duration - to September 1966).
Personnel: 1 engineer, 1 forester.
Principal Investigator: G. D. Kelly.

Special Equipment: Soil erosion gage, filter catchment.

130 HYDROLOGY OF WATER YIELD PREDICTION: Oregon State University, Corvallis.

Project Objectives:

(1) To develop means of predicting water yield using meteorological parameters for watersheds of heterogeneous vegetation.
(2) To determine changes in water yield caused by logging.

A detailed examination has been made of several projects with similar components in other parts of the country to assist in equipment selection. Purchasing of equipment is nearly complete and field installations are well underway. Sub-projects have been developed as outlined below:

(1) Peak discharge investigations on small, coastal watersheds.
(2) Development of methodology to predict low flows, using the experimental watersheds on the coast.
(3) Developing the energy budget as a predictive tool for evapotranspiration with different forms of vegetation, slopes, and aspects.
(4) Applying the water budget to precipitation in contrasting stands of conifers and hardwoods to determine interception losses, soil moisture changes, and other factors.
(5) Obtaining information on water movement within forest soil profiles.
(6) Analyzing the presently used methods of predicting low flows with a view toward developing methods for regional and subregional prediction and for assessing yield for a basin subject to changing watershed conditions.

Project Started: May 1965 (duration - long term).
Personnel: 2 engineers, 2 foresters, 1 soil scientist.
Principal Investigator: J. T. Krygier.

131 EFFECTS OF PESTICIDES ON ESTUARINE ORGANISMS: Department of Fisheries and Wildlife, Oregon State University, Corvallis.

Project Objectives:

(1) To evaluate, through short-term bioassays, the acute toxicity to certain estuarine organisms of the insecticide Sevin.
(2) To determine the effects of Sevin and other pesticides on a community of organisms in artificial mud flats.
(3) To follow the residual life and metabolism of Sevin in estuarine organisms and in their environment.
(4) To determine the chronic effects of Sevin and other pesticides on an estuarine mollusk, crustacean, and a fish exposed to sublethal concentrations of the pesticides.

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Short-term bioassays have been completed with 10 species of estuarine animals using the insecticide Sevin and its first breakdown product, alpha naphthol. Studies on the breakdown of Sevin and alpha naphthol in sea water and bay mud have been conducted as well as the breakdown of these compounds. Studies have been initiated on the effect of Sevin in some enzyme systems in the Dungeness crab, and on the growth of cockle clams.

Project Started: May 1964 (duration - to April 1967).
Personnel: 2 chemists, 5 biologists.
Principal Investigator: R. E. Millemann.

132 STUDY OF BEGGIATOA SPECIES: Oregon State University, Corvallis.

Beggiatoa, commonly known as a sewage fungus, has been an obscure organism in relation to its metabolism, isolation, cultural conditions, and its ability to oxidize various sulfur compounds as an energy source. This investigation has definitely demonstrated that it does not derive its energy source from the oxidation of sulfur and therefore is not an autotrophic organism. Research has determined a method of cultivation and revealed some of its basic metabolis systems.

Project Started: July 1958 (duration - 8 years).
Personnel: 2 microbiologists.
Principal Investigator: Richard Y. Morita.

Publications: The influence of catalase and cultural conditions on Beggiatoa. J. Bact. 88:1755-1761. 1964.

Filamentous appendages of Thiothrix. Z. Allg. Mikrobiol. 5:177-179. 1965.

Utilization of acetate by Beggiatoa. J. Bact. 91:1192-1200. 1965.

133 BASIC NATURE AND ENVIRONMENTAL RESPONSE OF MARINE PSYCHROPHILIC BACTERIA: Oregon State University, Corvallis.

This investigation seeks to determine the basic reasons why psychrophilic bacteria require low temperature for growth as well as why they will not grow, but expire, at moderate temperatures of 20 to 30 C. Thus far studies have indicated that the existence of psychrophilic that have optimum temperatures for growth (below 20° C) are very common in the marine environment, even though they have

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been neglected by microbiologists. Temperature above that for optimum growth for *Vibrio marinus* MP-1 has shown to be lethal - mainly because malic dehydrogenase of the organism becomes inactivated and also because thermal-induced leakage of cellular materials occurs. The above studies are essential to determine why temperature is an environmental parameter. Furthermore, the activities of marine psychorphiles can be important if organic materials in the water are to be decomposed.

Project Started: July 1, 1965 (duration - 3 years).
Personnel: 6 microbiologists.
Principal Investigator: Richard Y. Morita.

Publications: Moderate temperature effects on oxygen uptake of *Vibrio marinus*. *Bact. Proc.* 1964. p. 38-39.

Reisolation and emendation of description of *Vibrio marinus* (Russell) Ford. *J. Bact.* 88:831-837. 1964.

Taxonomy of marine vibrios. *Bact. Proc.* 1964. p. 37

Temperature effects on the growth of an obligate psychrophilic marine bacterium. *Limnol. Oceanogr.* 9:103-106. 1964.

Cell yields of *Vibrio marinus*, an obligate psychrophile, at low temperatures. *Can. J. Microbiol.* 11:221-227. 1965.

Kinetics of enzyme reactions and synthesis in obligate psychrophilic bacteria. *Bact. Proc.* 1965. p. 20.

Leakage of cellular materials from *Vibrio marinus* induced by moderate temperature. *Bact. Proc.* 1965. p. 30.

Physiological differences between cells of *Vibrio marinus* grown at 4 and 15 C. *Bact. Proc.* 1965. p. 20.

Temperature-hydrostatic pressure effects on deamination of L-serine by *Vibrio marinus*. *Bact. Proc.* 1965. p. 20.

The effect of moderate temperature on *Vibrio marinus*, an obligate psychrophilic bacterium. *J. Gen. Microbiol.* 41:xxvi-xxvii. 1965.

Marine psychrophilic bacteria. *Oceanogr. and Mar. Biol.*: an annual review. 4:105-121.

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The effect of moderate temperature on the respiration and viability of Vibrio marinus. Z. Allg. Mikrobiol. 6:181-187. 1966.

Deep-sea microbiology - effects of hydrostatic pressure and low temperature. University of Maryland's lecture series. 1966. 12 pp.

134 HYDROSTATIC PRESSURE EFFECTS ON MICROBIAL ACTIVITIES: Oregon State University, Corvallis.

The objective is to determine the effect of hydrostatic pressure on the metabolis activities of microorganisms. The pressures employed fall between the ranges of 1 to 1100 atm., equivalent to the environmental hydrostatic pressures that exist in the ocean. Emphasis has been placed on the effect of coupling the parameters of hydrostatic pressure and temperatures on enzyme activities. Data have been interpreted in terms of molecular volume increases and decreases. Generally pressure decreases molecular volume and temperature increases molecular volume. Hence both parameters must be studied in order to determine why organisms can or cannot metabolize under the various conditions of temperature and pressure that exist in the ocean.

Project Started. 1959 (duration - 9 years).
Personnel: 4 microbiologists.
Principal Investigator: Richard Y. Morita.

Special Equipment: hydrostatic pressure apparatus.

Publications: Dehydrogenase activity under hydrostatic pressure by isolated mitochrondria obtained from Allomyces macrogynus. Limnol. Oceanogr. 9:243-248. 1964.

The influence of substrate-cofactor ratios on partially purified inorganic pyrophosphatase activity at elevated temperatures. J. Bact. 88:1661-1666. 1964.

Effect of hydrostatic pressure. In: Ainsworth and Sussman (ed). 1965. The Fungi. Academic Press, New York. Vol. 1, chapter 22.

Temperature-hydrostatic pressure effects on deamination of L-serine by Vibrio marinus, an obligate psychrophile. Bact. Proc. 1965. p. 20.

Deep-sea microbiology - effects of hydrostatic pressure and low temperature. University of Maryland's lecture series. 1966. 12 pp.

135 COMMUNICATION SYSTEM FOR WATER QUALITY DATA ACQUISITION: Oregon State University, Department of Electrical Engineering, Corvallis.

Project Objectives:

To optimize a communications network for retrieval of water resources management data by developing a communications model describing location, distribution, and other factors for seven water quality monitoring stations in the Willamette River Basin, Oregon.

Monitoring station locations and the demand for water quality data have been analyzed for periods of 5, 15, and 30 years into the future. A system analysis of the communication network required to handle the future data load is being carried out with particular emphasis on a comparison of VHF radio links versus ground wire communications.

Project Started: September 1965 (duration - one year).
Personnel: 1 engineer.
Principal Investigator: D. W. Newbern.

136 EFFECT OF SELECTED PESTICIDES ON BIOCHEMICAL OXYGEN DEMAND: Oregon State University, Corvallis.

Project Objectives:

To investigate the effect of several pesticides on the biochemical oxygen demand of a glucose-glutamic acid substrate by evaluating reaction rates, ultimate biochemical oxygen demand, and any suppression of second stage nitrification.

Project Started: September 1965 (duration - to August 1966).
Personnel: 1 engineer.
Principal Investigator: F. W. Norris,.Jr.

137 ECOLOGICAL STUDIES OF RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY AND ADJACENT PACIFIC OCEAN: Oceanography Department, Oregon State University, Corvallis.

The objective of this project is to determine the fate of radionuclides in the estuarine and marine environment and the manner by which ecological communities modify the distribution of radioactivity.

Projects are being carried out in three areas: radioecology of the benthos, radioecology of nekton and macroplankton, and radiochemistry. These projects, too numerous and extensive to outline here, are summarized in a progress report (Oceanography Ref. 65-14) prepared by the project leader and submitted to the granting agency. Copies of this report may be obtained from the principal investigator.

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Project Started: November 1965 (duration - to October 1966).
Personnel: 7 oceanographic chemists, 9 oceanographic biologists.
Principal Investigator: Charles Osterberg.

Special Equipment: 3 multi-channel gamma ray spectrometers, 1 atomic absorption spectrometer, 2 *in situ* gamma ray detectors, various closing nets and samplers.

Publications: Cutshall, N., V. Johnson and C. Osterberg. 1966. Chemistry of chromium-51 in sea water. *Science* 152:202-203.

Cutshall, N. and C. Osterberg. 1964. Radioactive particle in sediment from the Columbia River. *Science* 144(3618):536-537.

Jennings, C. David. 1966. Radioactivity of sediments in the Columbia River estuary. M.S. Thesis, Oregon State University.

Jennings, D., N. Cutshall and C. Osterberg. 1965. Radioactivity: detection of gamma-ray emission in sediments *in situ*. *Science* 148(3672):948-950.

Johnson, Vernon. 1966. Retention of zinc-65 by Columbia River sediment. M.S. Thesis, Oregon State University.

McCauley, J. E. 1964. A deep sea digenetic trematode. *J. Parasit.* 50(1):112-114.

McCormick, J. M. 1965. Some aspects of the ecology of hydroids off Oregon. *NW Sci.* 39(4):139-147.

Osterberg, C. 1965. Radioactivity from the Columbia River. Trans. of the Oc. Sci. Engr. Symposium 2:968-979.

Osterberg, C., A. G. Carey, Jr. and H. Curl, Jr. 1963. Acceleration of sinking rates of radionuclides in the ocean. *Nature* 200 (4913):1276-1277.

Osterberg, C., N. Cutshall and J. Cronin. 1965. Chromium-51 as a radioactive tracer of Columbia River water at sea. *Science* 150: 1585-1587.

Osterberg, C., L. D. Kulm and J. V. Byrne. 1963. Gamma emitters in marine sediments near the Columbia River. *Science* 139:916-917.

Osterberg, C., J. G. Pattullo and W. Pearcy. 1964. Zinc-65 in euphausiids as related to Columbia River water off the Oregon coast. *Limnol. Oceanogr.* 9(2):249-257.

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Osterberg, C., W. G. Pearcy and H. Curl, Jr. 1964. Radioactivity and its relationship to the oceanic food chains. J. Mar. Res. 22(1):2-12.

Osterberg, C., W. G. Pearcy and N. F. Kujala. 1964. Gamma emitters in a fin whale. Nature 204(4692):1006-1007.

Osterberg, C., L. Small and L. Hubbard. 1963. Radioactivity in large marine plankton as a function of surface area. Nature 197(4870):883-884.

Pearcy, W. G. 1964. Some distributional features of mesopelagic fishes off Oregon. J. Mar. Res. 22(1):83-102.

Pearcy, W. G. and L. Hubbard. 1964. A modification of the Isaacs-Kidd midwater trawl for sampling at different depth intervals. Deep Sea Res. 11:263-264.

Pearcy, W. G. and C. Osterberg. 1964. Vertical distribution of radionuclides as measured in oceanic animals. Nature 204(4957): 440-441.

Renshaw, R. W. and W. G. Pearcy. 1964. A new swivel cable clamp for towing large plankton nets at different depths. Deep Sea Res. 11:263-264.

138 STUDIES ON AQUATIC MYXOBACTERIA: Oregon State University, Corvallis.

The major objectives of this investigation are to obtain data on the occurrence and taxonomy of myxobacteria in the aquatic habitat in order to gain an understanding of the roles of these organisms in the freshwater environment. In particular it is of interest to determine the importance of these organisms in the decomposition of pollutional materials and their possible application in water quality surveillance and purification of water. It is planned to isolate and characterize myxobacteria from both pure and polluted waters and to study the interrelationships between these organisms and their environment. These studies will contribute to our knowledge concerning the bacterial flora of the aquatic habitat, an area which has not been adequately studied.

Project Started: January 1966 (duration - 3 years).
Personnel: 4 microbiologists.
Principal Investigator: Robert E. Pacha.

139 AN INVESTIGATION OF FLUXES OF DISSOLVED GASES AND NUTRIENTS RELATING TO BIOCHEMICAL AND AERATION PROCESSES OFF THE OREGON COAST: Oregon State University, Corvallis.

Project Objectives:

(1) To investigate aeration phenomena of different gases in the open ocean during various seasons.
(2) To study the correlation between the changes in dissolved nutrients (phosphate and nitrate) and dissolved gases (oxygen and carbon dioxide) in order to help us understand the biochemical oxygen reduction process in the ocean.
(3) To measure influxes of nutrients to the euphotic zone off Oregon from the Columbia River and upwelling to gain a better understanding of the nutrient budget and fertility of our region.

Project Started: November 1965 (duration - to October 1967).
Principal Investigator: Kilho Park.

140 ALKALINITY OF SEA WATER: Oregon State University, Corvallis.

Project Objectives:

(1) To develop a conductometric method for the determination of the alkalinity of sea water to a precision of 0.1%.
(2) To investigate the invariant properties of alkalinity.
(3) To investigate the temperature dependency of the conductometric method.

A continuous cell is being evaluated in the laboratory. A precision of 0.5% in alkalinity measurements is readily obtainable. We hope to improve on this precision. Data on seasonal changes in alkalinity in both the Columbia River and the sea off Oregon show that we can forecast the alkalinity of the Columbia River plume, if we know its salinity.

Project Started: May 1964 (duration - to April 1966).
Principal Investigator: Kilho Park.

Publications: Park, K. 1964. Electrolytic conductance of sea water: effect of calcium carbonate dissolution. Science 146 (3640):56-57.

Park, K. and W. V. Burt. 1965. Electrolytic conductance of sea water and the salinometer. A review. J. Oceanog. Soc. Japan 21:69-80;124-132.

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Park, K. 1965. Total carbon dioxide in sea water. J. Oceanogr. Soc. Japan 21(2):54-59.

Park, K. 1966. Columbia River plume identification by specific alkalinity. Limnol. Oceanogr. 11(1):118-120.

141 RELATIONSHIP OF AQUATIC FLORA TO WATER QUALITY AND POLLUTION: Oregon State University, Corvallis.

Project Objective:

(1) To determine the relation of aquatic flora to the quality of water supplies and water pollution.
(2) To determine by biological studies of aquatic habitats, the relation between the biotic and adaphic factors that determine changes in the quality of water resources.
(3) To coordinate and extend the phases of studies presently conducted in the general area of aquatic botany.

Several studies relating variations in temperature and current velocity to community metabolism have been completed and publications describing the studies will soon be available. A study of metabolic pathways utilized by Sphaerotilus is nearing completion and field work is completed on another of primary production in relation to stream enrichment. New laboratory streams are being prepared for studies of the effect of pesticides on algae metabolism and a series of studies is underway at the Newport laboratory, in regard to the effect of salinity variations upon marine algae metabolism using selected species from Yaquina Bay. Study of mineral metabolism of blue-green algal species from the nuisance bloom in Klamath Lake is continuing.

Project Started: 1958 (duration - continuing).
Personnel: 3 biologists.
Principal Investigators: H. R. Phinney, C. D. McIntire.

Publications: McIntire, C. David, Robert L. Garrison, Harry K. Phinney and Charles E. Warren. 1964. Primary production in laboratory streams. Limnol. Oceanogr. 9:92-102.

McIntire, C. David and Harry K. Phinney. 1965. Laboratory studies of periphyton production and community metabolism in lotic environments. Ecol. Monogr. 35:237-258.

Phinney, Harry K. and C. David McIntire. 1965. Effect of temperature on metabolism of periphyton communities developed in laboratory streams. Limnol. Oceanogr. 10:341-344.

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Phinney, Harry K. and C. A. Peek. 1961. Klamath Lake, an instance of natural enrichment. In: Trans. Seminar on Algae and Metropolitan Wastes. April 27-29, 1960. R. A. Taft Sanitary Engineering Center, Tech. Rep. W61-3:22-27.

142 FACTORS INFLUENCING STREAM TEMPERATURES: Engineering Experiment Station, Oregon State University, Corvallis.

The goal of this research work is to gain a better understanding of the phenomena of stream thermal behavior in a natural environment with no thermal pollution from sources other than those naturally occurring. Three factors are considered in particular: evaporation from stream surfaces; the absorption and reradiation of radiant energy by the water surface of a stream; and the effect of turbidity on the rate of heating and evaporation of the stream water mass.

Project Started: May 1, 1964 (duration - 4 years).
Personnel: 2 engineers, 4 students.
Principal Investigator: John Seaders.

Special Equipment: infrared thermometer, hot wire anemometer, X-Y recorder, solarimeter with solarigraph recorder, actinometer, hydrogrometer, 6 vane wind registering and recording equipment.

143 INFLUENCES OF WATER QUALITY AND OTHER ENVIRONMENTAL CHANGES ON FISH AND ASSOCIATED ORGANISMS IN INLAND WATERS: Oregon State University, Corvallis.

Project Objectives:

To provide fundamental understanding of the influences which generally occurring environmental changes have on fish and associated organisms in inland waters. The domestic, agricultural, forestry, industrial and other activities of man are continually changing the character of our inland waters and endangering their social and economic value. Understanding of the influences of these changes, to be of much scientific or social value, must be in terms of the individual organism, its population and its community, as associated with the stream ecology.

This program is subdivided into individual projects according to the supporting research grants, as described below:

(1) Long-term studies of the trophic dynamics of simplified communities in laboratory streams are underway along with

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aquarium experiments to determine respiration rates and assimilation efficiencies of selected species. Supplementary observations of cutthroat trout feeding behavior and drift feeding experiments have been conducted.

(2) Ecological studies of an experimental stream have involved food energy and production in enriched and natural sections of the stream, production and food consumption of cutthroat trout in two types of sections of the stream, and the relationship between fish size and kinds of food organisms consumed in both types of stream sections. Other work includes periodic sampling of invertebrates and organic material and an analysis has been made of data from physiological and ecological studies of algae and *Sphaerotilus*.

(3) As part of a study of the influence of dissolved oxygen upon the survival, development, growth, activity and movements of freshwater fishes, a series of experiments has been conducted to determine the influence of metabolic waste products on the growth of steelhead trout and chinook salmon embryos and sac fry. Another experiment series has been conducted to determine the influence of disease, parasite load, and time of year on the growth and mortality of juvenile coho salmon over a wide range of dissolved oxygen concentrations at a constant temperature.

(4) A new, long-range project has been added to this program to determine how and to what extent kraft pulp mill wastes that are neither acutely toxic nor severely oxygen depleting influence fish populations.

Project Duration: Long term.
Personnel: 10 biologists, 15 students.
Principal Investigator: C. E. Warren.

Publications: Davis, G. and C. E. Warren. 1965. Trophic relations of a sculpin in laboratory stream communities. *J. Wildl. Mgmt.* 29(4):846-871.

Doudoroff, P. and C. E. Warren. 1965. Dissolved oxygen requirements of fishes. In: Biological Problems in Water Pollution. Third Seminar, August 1962. U. S. Public Health Service. pp. 145-155.

McIntire, D. and H. Phinney. 1965. Effect of temperature on metabolism of periphyton communities developed in laboratory stream communities. *Limnol. Oceanogr.* 10:341-344.

McIntire, D. and H. Phinney. 1965. Laboratory studies of periphyton production and community metabolism in lotic environments. *Ecol. Monogr.* 35:237-258.

144 BIONOMICS OF FISHES AND SHELLFISHES WITH PARTICULAR REFERENCE TO THE ECOLOGICAL FACTORS AFFECTING BIOLOGICAL PRODUCTIVITY IN OREGON BAYS AND ESTUARIES: Oregon State University, Corvallis.

Project Objectives: To provide methods and scientific data as a guide for establishing water quality criteria for marine areas and predicting effects on marine organisms, by:

(1) Obtaining bionomic information of the important fishes and shellfish species of Oregon bays in relation to ecological factors (temperatures, salinities, currents, and tidal phases, pH, dissolved oxygen, carbon dioxide, turbidity, edaphic conditions, foods, industrial and domestic sewage wastes, etc.).
(2) Continuing the development of aquaculture procedures for oysters, clams, and other marine species of importance; particularly the rearing of oysters and clams from the free-swimming larva stage to seed stage.
(3) Obtaining reliable biological information as to the resistance and susceptibilities of marine organisms to various pollutional conditions occurring in marine waters.

The program is subdivided into individual projects according to supporting research grants, as described below:

(1) Preliminary examination has been made of data developed for the purpose of evaluating Pacific oyster larvae bioassay techniques, which includes factors such as incubation temperatures, water quality, salinity of the dilutant, and time of year.
(2) Investigation of pulp mill waste degradation in marine waters is being accomplished by evaluating the biological impact that raw and treated kraft mill waste components have upon the marine environment, and evaluating the potential treatment methods for such wastes in respect to the biological factors thus determined.
(3) Studies have been conducted to determine the influence of temperature, light, and salinity on the production of marine algae.

Project Duration: Long term.
Principal Investigator: C. E. Warren.

Publications: Dimick, R. E. 1965. Use of bay mussel Mytilus edulis as a bioassay tool for evaluating kraft mill waste. Proceedings 1964 Pacific Northwest Industrial Waste Conference. University of Washington.

145 BENTHIC FAUNAL INDICATORS OF POLLUTION IN COOS BAY, OREGON: Portland State College, Portland.

Project Objectives:

(1) To study the relation of biotic distribution to sources of pollution in Coos Bay.
(2) To train students in marine biology and to motivate them toward studies of the effects of pollution on marine organisms.
(3) To note the toxic effects of different types of pollutants on benthic organisms in the vicinity of outfalls.

Quantitative samples of bottom at different distances from sources of pollution were screened and examined to determine the numbers and kinds of bottom animals. Buckets were placed at different distances from outfalls to determine the types of animals that settle on the bottom and to get some indication of the growth of organisms settling in the vicinity of the outfalls, as well as in relatively unpolluted areas. Water samples were taken at collecting locations and were analyzed for D.O., pH, temperature, sulfite, sulphide, nitrate, silicon, phosphate and lignin. Trawl hauls and plankton collections were made where bottom collections had been made.

Project Started: June 1, 1960 (duration - to August 31, 1965).
Personnel: 3 biologists.
Principal Investigator: James A. Macnab.

Special Equipment: 26-foot semi-cabin cruiser, anchor dredge, mud sampler.

Publication: Long, Dale A., D. McKay-Fender and James A. Macnab. 1964. A preliminary survey of the sources and kinds of pollution in Coos Bay, Oregon. Portland State College, 27 pp.

146 SURVEY OF OREGON WATER LAW: School of Law, University of Oregon, Eugene.

This project is the first step in a long-range program to evaluate water management institutions such as water law, water use customs, water management agencies, and administrative regulations. Analysis is being made of Oregon court decisions, constitutional and statutory provisions, and Attorney General opinions regarding the use of surface and ground water resources of the state. The study is tracing historical development of Oregon water law, synthesizing and evaluating existing law, and critically comparing it with water law in other western states.

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Objectives:

(1) To conduct a survey of Oregon water law.
(2) To evaluate the adequacy of selected portions of Oregon water law such as pollution controls. .
(3) To assess the vitality of common law principles expressed in early Oregon decisions.
(4) To identify for further research legal problems of water resources management important to the Northwest.

Project Started: May 1965 (duration - to July 1966).
Personnel: 3 law students.
Principal Investigator: C. D. Clark.

UTAH

147 LIMNOLOGICAL STUDIES OF THE COLORADO RIVER IN THE VICINITY OF MOAB, UTAH: Department of Zoology and Entomology, Brigham Young University, Provo.

The principal aims of the preliminary phase of this study were fourfold:

(1) To discern the physical and chemical nature of the river water.
(2) To determine the composition of the biotic communities.
(3) To attempt to relate the occurrence and activities of the organisms to the abiotic environment.
(4) To account for the biological productivity of the river, utilizing knowledge gained from studies of community metabolism and the cycling of matter and energy to and from the living and non-living components of the ecosystem.

Project Started: November 1961 (duration - indefinite).
Personnel: 1 chemist, 2 biologists.
Principal Investigators: H. H. Frost, J. R. Murphy, and J. H. Wing.

Publications: Frost, H. H. and J. R. Murphy. Observations on birds along the Colorado in the vicinity of Moab, Utah.

Frost, H. H., J. R. Murphy, J. H. Wing, and S. S. Taba. Progress report no. 2, limnological studies of the Colorado River in the vicinity of Moab, Utah (submitted to Texas Gulf Sulphur Company).

Taba, S. S., J. R. Murphy, and H. H. Frost. Notes on the fishes of the Colorado River near Moab, Utah.

148 BIOASSAYS TO DETERMINE THE TOXICITY OF PESTICIDES TO AQUATIC INVERTEBRATES: University of Utah, Salt Lake City.

Bioassays are being conducted with insecticides to determine their toxicity and sublethal effects to aquatic invertebrates. The project objectives are as follows:

(1) To determine if a particular insecticide or herbicide is toxic to those species of invertebrates which are important as fish food.
(2) To determine the level of toxicity under conditions of short and long time exposures and safe levels for certain periods of exposure.

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(3) To determine the relative toxicity of pesticides between fish and fish food organisms.
(4) To determine the physiological response of selected key organisms to sublethal concentrations of different pesticides.
(5) To ascertain, if possible, any subtle, indirect and long-range effects these toxicants may have on the balance between the various components in selected aquatic communities.
(6) To determine how the toxicity of various pesticides varies with changes in water quality characteristics.
(7) To determine rates and levels of precipitation, chemical change, and absorption of test materials at various time intervals.

Project Started: January 1, 1959 (duration - to December 31, 1967).
Personnel: 2 chemists, 2 biologists.
Principal Investigator: Arden R. Gaufin.

Special Equipment: Jarrell-Ash gas chromatograph, continuous-flow bioassay system.

Publications: Gaufin, A. R., L. D. Jensen, A. V. Nebeker, T. Nelson and R. W. Teel. 1965. The toxicity of ten organic insecticides to various aquatic invertebrates. Wat. Sewage Wks. July 1965. 4 pp.

Jensen, L. D. and A. R. Gaufin. 1964. Effects of ten organic insecticides on two species of stonefly naiads. Trans. Am. Fish. Soc. 93(1):27-34.

Jensen, L. D. and A. R. Gaufin. 1964. Long-term effects of organic insecticides on two species of stonefly naiads. Trans. Am. Fish. Soc. 93(4):357-363.

Nebeker, Alan V. and Arden R. Gaufin. 1964. Bioassays to determine the toxicity of pesticides to the amphipod crustacean, Gammarus lacustris Sars. Proc. Utah Acad. Sci., Arts and Letters 41(1):64-67.

Warnick, S. L. and A. R. Gaufin. 1965. Determination of pesticides by electron capture gas chromatography. J. Am. Wat. Wks. Assn. 57(8):1023-1027.

149 A STUDY OF THE BIOLOGICAL, CHEMICAL AND PHYSICAL NATURE OF WATER QUALITY FACTORS UNDER UTAH CONDITIONS: Utah State University, Logan.

The characteristics and relationships of water quality factors pertinent to short, snow-fed mountain streams feeding to desert floors will be studied. Consideration will be given to watershed contamination,

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irrigation return flow, and domestic and industrial pollution. The relationship of the contaminant to volume of flow, rate of degradation and subsequent incorporation into the aquatic biomass will be the matter of primary concern. Contaminant cycling, sedimentation and physical change will also be studied. The system under study will lend itself to model construction in terms of the environmental, physical, chemical and biological effects of contaminants. The information for such a model will be obtained from field observations and from experiments conducted on excised portions of the environment.

Project Started: April 1, 1965 (duration - 10 years).
Personnel: 2 engineers, 1 chemist, 4 biologists, 1 microbiologist.
Principal Investigator: John M. Neuhold.

Special Equipment: electronic particle counter, gas analyzers

Publications: Progress Report, 1965.

150 **EFFECT OF MINERALIZED SPRINGS ON UTAH'S WATER RESOURCES:** Utah State University, Logan.

Project Objectives:

(1) To obtain an inventory of mineralized spring waters with respect to location, hydrologic and geologic setting, and quantity and quality of water.
(2) To appraise current and potential effects of these springs on important usable supplies.
(3) Evaluate possible management and control measures aimed at extending the usefulness of principal water supplies.

Project Started: June 1964 (duration - 2 years).
Personnel: 2 engineers, 1 geologist.
Principal Investigator: Jay M. Bagley.

Publications: Paper presented at Seattle American Geophysical Union meetings, Dec. 1964.

WASHINGTON

151 WATER QUALITY CONDITIONS IN THE LAKE WASHINGTON SHIP CANAL: Municipality of Metropolitan Seattle.

Water quality characteristics of the Lake Washington Ship Canal are being studied to determine their improvement in this major recreational and fish migration watercourse as a result of the pollution abatement program of the Municipality of Metropolitan Seattle. Present areas of interest include oxygen balance and coliform indices. Study is also being continued on salt water intrusion, previously conducted by the U. S. Army Corps of Engineers. Other possible areas of interest include plankton productivity, nutrient balance and bottom sampling.

Project Started: June 1964 (duration - indefinite).
Principal Investigators: Metro staff.

152 NUTRIENT STUDIES OF LAKE WASHINGTON TRIBUTARIES: Municipality of Metropolitan Seattle.

This project is designed to compliment the work being performed by Dr. W. T. Edmondson on the eutrophication of Lake Washington. Nutrient inflow, outflow and reservoir are being determined to help assess the effect of removal of a major nutrient source from the lake represented by the many sewage treatment plants being phased out by the municipality.

Project Started: 1963 (duration - indefinite).
Principal Investigators: Metro staff.

153 EFFECTS OF WASTE DISPOSAL INTO PUGET SOUND WATERS ADJACENT TO METROPOLITAN SEATTLE AREA: Municipality of Metropolitan Seattle in coordination with U. S. Geological Survey, Water Resources Division.

This program is designed to determine the effects of discharging treated wastes into Puget Sound from one major and three smaller marine outfalls. Data are being collected on oxygen balance, coliform indices, density profiles, plankton production, nutrient budget and physical contamination under pre- and post-discharge conditions. This includes study of the influence of the present raw sewage outfall. Also to be studied are the dilution and dispersal of the digested sludge to be discharged at West Point as well as its effect on the benthic community and organic solids buildup.

Project Started: 1964 (duration - indefinite).
Principal Investigators: Metro and Geological Survey staffs.

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Special Equipment: 40 foot survey vessel, scaler and detector system for Carbon-14, carbon analyzer, fluorometer, ortholux microscope and 2 inverted microscopes, oceanographic sampling gear.

154 A STUDY OF THE WATER QUALITY, ECOLOGY AND HYDROLOGY OF THE GREEN-DUWAMISH ESTUARY: Municipality of Metropolitan Seattle in cooperation with U. S. Geological Survey, Water Resources Division.

This study is designed to provide basic data on the ecology and water quality of the river system following a major pollution abatement program. Four automatic monitors are being used to complement manually collected data on plankton production, flushing rates, sediment transport, nutrients, BOD, benthic organisms and fish distribution and abundance. The study will provide information necessary to ensure that water quality conditions are not impaired by Metro's new Renton Treatment Plant.

Project Started: 1961 (duration - indefinite).
Principal Investigators: Cooperative effort of several investigators.

Special Equipment: carbon analyzer, radioactive counting equipment, polarograph, four Engineering Specialties robot monitors and central station, ortholux microscope and two inverted scopes, turner, Beckman model B spectrophotometer.

Publications: Special Duwamish River Studies, Water Quality Series #1.

155 A LIMNOLOGICAL INVESTIGATION OF WATER QUALITY CONDITIONS IN LAKE SAMMAMISH, WASHINGTON: Municipality of Metropolitan Seattle, Washington.

This project was designed to provide needed background information on the limnology of this important lake. Metro's ultimate plans call for providing trunk sewers to intercept wastes presently entering the lake from one treatment plant and from numerous septic tanks. Included in the study were oxygen deficit calculations, nutrient analyses, oxygen determinations, chlorophyll, seston, phytoplankton number and volume, and zooplankton enumeration. Sampling was carried out weekly for 18 months and a report is being prepared.

Project Started: June 1964 (duration - to December 1965).
Principal Investigator: Gary Isaac.

Special Equipment: microscopes - Ortholux and Leitz inverted, a wide variety of limnological equipment.

156 RESERVOIR LIMNOLOGY: Washington State Department of Fisheries, Brinnon.

The first phase dealt with problems of fish passage through the reservoirs and this phase dealt primarily with physical and chemical limnology, determination of flow patterns, seasonal cycles, etc. The current work is aimed at possible rehabilitation of reservoirs for use as salmon rearing areas. This phase of the work deals primarily with biological and chemical limnology. Measurements are made of chemical nutrients, primary productivity, and secondary productivity.

Project Started: March 1962 (duration - continuing).
Principal Investigator: R. E. Westley.

157 ESTUARINE PESTICIDE MONITORING: Washington State Department of Fisheries, Brinnon.

Samples of adult Pacific oysters are collected monthly at 18 locations covering all major salt water areas of Washington state. These samples are prepared and shipped to Gulf Breeze, Florida, where they are analyzed for aldrin, BHC, chlordane, dieldrin, DOD, DDE, DDT, endrin, heptachlor, heptachlor expoxide, lindane, and methoxychlor.

Project Started: September 1965 (duration - one year).
Principal Investigator: C. E. Lindsay.

158 CHEMICAL CONTROL OF OYSTER PREDATORS: Washington State Department of Fisheries, Brinnon.

Project Objectives:

Carry out commercial scale experiments to control ghost and land shrimp with the insecticide Sevin. Issue permits for treatment of specified areas, quantity of chemicals used, and methods of application. Observe effect of application and report on results after treatment. Conduct tests on several types of chemicals reported to be effective molluscacides. Determine necessary dosages and application methods to achieve eradication of oyster drills. Advise shellfish industry on proven methods for control of pests and predators.

Project Started: 1959 (duration - continuing).
Principal Investigator: Cedric E. Lindsay.

159 OYSTER BED PRODUCTIVITY STUDY: Washington State Department of Fisheries, Brinnon.

This is a study to determine relationships between hydrographic characteristics of bays and oyster growth, fatness and mortality. Emphasis is on primary productivity and fertility of water. Relationships to oyster fatness have been fairly well worked out. Current work is on mortality.

Project Started: 1961 (duration - continuing).
Principal Investigators: R. E. Westley, M. A. Tarr, C. S. Sayce.

160 BIOASSAY OF MARINE WATERS OF THE STATE OF WASHINGTON: Washington State Department of Fisheries, Brinnon.

Bioassays using the 48-hour development of Pacific oyster eggs are conducted for all applicable Washington waters. Samples are taken by float plane and flown to the Pt. Whitney laboratory where they are bioassayed. Chemical analysis of the water is made in conjunction with the bioassay. Areas sampled are Northern Puget Sound, Southern Puget Sound, Straits of Juan de Fuca, Grays Harbor, and Willapa Bay.

Project Started: 1961 (duration - continuing).
Principal Investigator: Charles E. Woelke.

161 WASHINGTON STATE DEPARTMENT OF HEALTH COMMUNITY PESTICIDE STUDY PROJECT: Washington State Department of Health, Wenatchee.

This is one of 13 projects in the United States involved in basic health related research on pesticide residues in the environment and in human tissues. Project objectives include:

(1) Analysis of human tissues for pesticides whose source may be related to water pollution and consumption.
(2) Epidemiological studies of possible disease incidence related to pesticides.
(3) A comprehensive survey of pesticide usage including risk of water pollution.
(4) Monitoring the environment, including pre-treatment water supplies and treated water supplies. Irrigation supplies to and discharges from soils of known pesticide treatment will be studied.

The Wenatchee and Quincy Valleys will be the primary study area for monitoring pesticide content in soil and water. Initial water samples are to be taken from localities previously used by the U. S. Department of Agriculture for soil monitoring studies. Continued sampling of the study area will begin as soon as grid localities

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are established on topography maps. Objectives related to collaborative studies with other agencies: The Columbia Basin Irrigation Project lands will be studied in cooperation with the Federal Water Pollution Control Administration. The British Columbia Public Health Service and the CPSP are planning quality control water samples from the Okanogan River at the U. S. - Canadian border.

Project Started: March 1965 (duration - to March 1970).
Personnel: 1 medical director, 1 research sanitarian.
Principal Investigator: Griffith E. Quinby, M.D.

Special Equipment: 2 gas chromatographs, 2 thin layer chromatographs, 1 infrared spectrophotometer.

162 LABORATORY BIOASSAYS WITH TEST FISH CICHLISOMA SP: Washington State Pollution Control Commission, Olympia.

The objectives are to determine the toxicity of various chemicals to cichlids and compare the results with similar data available in the literature pertaining to salmonids; and to gain more knowledge of this test fish so it can be used to evaluate the toxicity of industrial wastes. Bioassays are being conducted using cichlids and various acids, alkalies, heavy metals, chlorinated hydrocarbons and industrial wastes. The project has not advanced sufficiently to present data on comparative toxicities.

Project Started: June 1965 (duration - continuous).
Personnel: 2 biologists.
Principal Investigator: Roland E. Pine.

Special Equipment: gas chromatograph.

163 EFFECTS OF INACTIVATION OF ENTERIC VIRUSES BY ULTRAVIOLET RADIATION IN SEA WATER: U. S. Public Health Service, Division of Environmental Engineering and Food Protection, Northwest Shellfish Sanitation Laboratory, Gig Harbor.

Project Objectives:

To continue studies on the comparison of susceptibility of enteroviruses to ultraviolet irradiation under various conditions in sea water. Factors such as salinity, temperature, turbidity, organic and biological materials will be studied to determine whether each facilitates or retards rate of inactivation.

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Project Started: September 1965 (duration - three years).
Personnel: 2 microbiologists.
Principal Investigator: Dr. J. C. Hoff.

Special Equipment: Ultra-high centrifuge.

164 ECOLOGICAL STUDIES FOR PRESENCE OF TOXIN-PRODUCING GRAM POSITIVE SPORE-FORMING BACTERIA: U. S. Public Health Service, Division of Environmental Engineering and Food Protection, Northwest Shellfish Sanitation Laboratory, Gig Harbor.

Project Objectives:

To continue investigations on the incidence of toxin-producing gram positive spore-forming bacteria in polluted and non-polluted fresh and estuarine mud and sewage, as related to shellfish growing areas. Surveys will be made on West Coast estuarine areas where commercially important shellfish are present. Intensive studies will be made in an unpolluted shellfish growing area and tributary stream complex, as well as a polluted area where shellfish may be found.

Project Started: February 1965 (duration - 3 years).
Personnel: 2 microbiologists.
Principal Investigators: William J. Beck and T. H. Ericksen.

Special Equipment: anaerobic incubation apparatus.

165 INFLUENCE OF WET STORAGE ON THE COMMERCIAL HANDLING OF SHELLFISH: U. S. Public Health Service, Division of Environmental Engineering and Food Protection, Northwest Shellfish Sanitation Laboratory, Gig Harbor.

Project Objectives:

To determine the effects of tidal action and subsequent flow of fresh and saline waters on shellfish held in storage in an estuary during several tide changes. Parameters to be tested include bacteriology, temperature, and salinity on overlying waters, plus bacteriology on shellfish held in storage containers.

Project Started: November 1965 (duration - 2 years).
Personnel: 2 microbiologists.
Principal Investigators: Walter Jakubowski and George Vasconcelos.

Special Equipment: special float for storage of shellfish.

166 NORTHWEST WATERSHED PROJECT: U. S. Public Health Service, Division of Environmental Engineering and Food Protection, Interstate Carrier Branch, Gig Harbor.

Project Objectives:

To make physical, chemical, bacteriological and virological surveys of three watersheds in the Pacific Northwest. All three watersheds are sources of potable water for large cities. Two of the watersheds are closed to the public, while one is open for recreational purposes.

Project Started: October 1965 (duration - 3 years).
Personnel: 2 engineers, 2 microbiologists.
Principal Investigator: R. W. Coene.

Special Equipment: water sampler for virus collection.

167 DETERMINATION OF METHODS FOR RECLAMATION OF WATER FOR REUSE IN FISH CULTURE: U. S. Bureau of Sport Fisheries and Wildlife, Longview.

The objective of this investigation is to develop methods for the reconditioning of water for reuse in hatchery operations, thereby increasing the production capacity of a given water supply. Bacterial beds have been developed where nitrifying bacteria converts deleterious ammonia to harmless nitrate, thereby permitting the reuse of water after aeration. Work has progressed to the point where it has been possible to reuse water as much as 50 times for fish culture. Large scale prototype testing and refinements for temperature control and disinfection of the water supply remain to be explored.

Project Started: June 1963 (duration - to March 1967).
Personnel: 2 engineers, 1 chemist, 2 biologists.
Principal Investigators: Roger E. Burrows and Bobby D. Combs.

Publications: Quarterly and annual reports, Division of Fishery Research, Bureau of Sport Fisheries and Wildlife.

168 PREDICTION AND CONTROL OF ENVIRONMENT IN THE UPPER COLUMBIA AND MIDDLE SNAKE RIVER BASINS: U. S. Bureau of Commercial Fisheries, Fish-Passage Research Program, Seattle.

Limnological, hydrological and meteorological data collected show that the temperatures in the Columbia and Snake Rivers will continue to rise with further impoundment of these rivers unless preventive measures are taken. This rise in temperature is incompatible with salmonid fishes using the river for spawning, rearing, and migration. Increased survival of the spawning stocks would occur if temperatures

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were lowered 15 degrees F. during the summer period. Methods of controlling water temperature are being sought for the new Canadian storage projects on the Columbia and Snake Rivers. It has been predicted, on the basis of incomplete data, that the cooler water which is expected to be delivered from high dams in the Middle Snake River can be carried through the proposed lower river reservoirs and dams to the Columbia River. Also, if cooler water is delivered to Chief Joseph Reservoir, there will be a gradual warming but cooler water will be carried through the proposed reservoirs to the lower Columbia River. It has been apparent during the past year that waters of the Columbia from Grand Coulee to Bonneville Dams and the lower Snake River are supersaturated with nitrogen. This supersaturation is highest during high flows when water is plunging over spillways. Surveys are in progress to determine the extent of supersaturation during all times of the year and to determine the effect of high nitrogen content on salmon.

Project Started: 1964 (duration - 7 years).
Personnel: 3 engineers, 3 biologists.
Principal Investigator: George R. Snyder.

Publications: Burt, Wayne V. 1963. Preliminary study on the predicted water changes of the Lower Snake River due to effects of projected dams and reservoirs. Part 1. Forecasting water temperature changes due to flow through intermediate depth reservoirs. Final report to the U. S. Bureau of Commercial Fisheries, Water Research Associates, Corvallis, Oregon, Nov. 1963. Processed.

Novotny, Anthony J. 1964. Importance of water temperature in the main stems of the Columbia and Snake Rivers in relation to the survival of salmon. Processed.

Raphael, Jerome M. 1964. The effect of Chief Joseph Dam on temperature in the Columbia River. June 1964. Consultant Civil Engineer, Berkeley, California. Processed.

Snyder, George R. 1964. Potential source of cool water for fish facilities in the Columbia River Basin. September 1964. Processed.

169 WATER YIELD IMPROVEMENT, EROSION CONTROL, AND SEDIMENT REDUCTION IN MIXED-CONIFER FOREST TYPES AND FOREST RANGES OF THE MID-COLUMBIA RIVER BASIN: U. S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Wenatchee.

In the mid-Columbia River system, most of the water available for irrigation, hydroelectric power, and domestic or industrial use originates in the alpine zone, upper-slope forests, and ponderosa pine grasslands occupying approximately 30 percent of the total area. The quantity and quality of raw water supplies depend upon the condition of these headwater areas where timber, forage, and recreation are also essential products. Adequacy of future water supplies depends upon how well technology is developed for management of watershed resources, and there is great need for information on management of forest lands for their maximum contribution to usable water supplies. The project objectives are to determine how moisture disposition and use are influenced by forest and range environments, climate, vegetative type, and soils; to relate incidence of erosion to characteristics of soils, vegetation, topography, climate and land use; and to develop sound principles and effective techniques for improving water yields while maintaining or restoring site stability in the mixed conifer forest and related range types of the mid-Columbia River Basin in eastern Washington and Oregon.

Project Started: 1956 (duration - continuing).
Personnel: 1 chemist, 1 biologist, 1 hydrologist, 1 meteorologist.
Principal Investigator: H. W. Berndt.

Special Equipment: neutron depth/moisture probes, Terra Scout portable seismograph, soil resistivity meter, plant growth control chamber, nitrogen analyzer, spectrophotometer (Beckman DU), gamma spectrometer (single channel).

Publications: Fowler, William B. 1964. Instrumentation for radiation sampling in the forest environment. Presented at 2nd Weather Bureau-USDA Conference on Research in Meteorology and Climatology, Washington, D.C., October 20, 1964.

Fowler, William B. 1964. The energy budget and its use in estimating evapotranspiration. Proceedings, Society of American Foresters, pp. 101-104.

Fowler, William B. 1965. Spatial sampling requirements and problems. Presented at Research Conference on Energy Balance, Washington, D. C. November 15-19, 1965.

Lopushinsky, William. 1964. Calcium transport in tomato roots. Nature 201(4918):518-519.

Wooldridge, David D. 1964. Effects of parent material and vegetation on properties related to soil erosion in central Washington. Soil Science Society of America Proceedings 28(3):430-432.

Wooldridge, David D. 1965. Soil properties related to erosion of wildland soils in central Washington. From Forest-Soil Relationships in North America. Paper presented at the Second North

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American Forest Soils Conference, Oregon State University, 1963. C. 1965 by the Oregon State University Press, Corvallis.

Wooldridge, David D. and Harold Weaver. 1965. Some effects of thinning a ponderosa pine thicket with a prescribed fire, II. J. For. 63(2):92-95.

Wooldridge, David D. 1965. Tracing soil particle movement with Fe-59. Proc. Soil Sci. Soc. Am. 29(4):469-472.

170 EFFECTS OF REACTOR EFFLUENT ON COLUMBIA RIVER WATER QUALITY: Battelle-Northwest, Division of Production, U. S. Atomic Energy Commission, Richland.

Project Objectives:

To develop improved relationships governing thermodynamics and dispersion phenomena in freshwater streams. By a combination of statistical studies, heat budget analyses, and internal energy balances determine the principal factors governing dispersion of effluent and the resulting water quality impact.

Detailed Objectives:

(1) Determine the net effect of Hanford operation on Columbia River temperature.
(2) Determine the net effect of Hanford operation on Columbia River chemical concentrations.
(3) Determine the shapes and extents of effluent plumes, including areas of maximum effluent concentrations and potential problem areas.

Project Started: October 1962 (duration - through 1968)
Personnel: 2 engineers, 5 technicians.
Principal Investigator: J. P. Corley.

Publications: Corley, J. P. 1964. Effects of Hanford operations on Columbia River temperatures - interim report HW-80888 CLASSIFIED SECRET.

171 SYSTEMS ENGINEERING MODEL OF THE COLUMBIA RIVER: Battelle-Northwest, Division of Production, U. S. Atomic Energy Commission, Richland.

Apply the heat budget method for synthesizing the thermal conditions characterizing the river regime. Use the digital computer to apply realistic transport treatment based on modeled velocity distribution.

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and density current factors. Minimize mathematical approximations such as coefficients, in order to take advantage of the computer memory for accounting. Having characterized the hydraulic regime, add additional surface interchange mechanisms such as dissolved gases.

Primary objective is to develop a real time model of the water quality factors in the Columbia River between Grand Coulee and the estuary. Secondary objective, pending additional support, is to model the entire Columbia and tributaries for parametric study and surveillance purposes.

Project Started: April 1963 (duration - 2 to 3 years).
Personnel: 1 engineer, 1 computation specialist, 1 mathematician.
Principal Investigator: R. T. Jaske.

Publications: Jaske, R. T. 1965. Prediction of Columbia River temperatures downstream from Grand Coulee Dam for wide extremes of flow and weather conditions. Contract report of U. S. Bureau of Commercial Fisheries. Contract 65B-RO-1440.

172 PARAMETRIC FACTORS GOVERNING HEAT TRANSPORT FROM LAKE ROOSEVELT: Battelle-Northwest, Division of Production, U. S. Atomic Energy Commission, Richland.

By a combination of statistical studies, heat budget analyses, and internal energy balances taken around Grand Coulee Dam and Lake Roosevelt, determine the principal factors governing the transport of heat to and from the lake. Develop a systems model to accurately predict thermal lags with application to other upstream construction projects. Develop additional insight into factors governing the optimization of water temperature for fish and nuclear production.

Project Started: July 1958 (duration - 3 to 5 years).
Personnel: 2 engineers, 1 mathematician.
Principal Investigator: R. T. Jaske.

Special Equipment: Univac 1107 computer and peripheral processing equipment.

Publications: Jaske, R. T. and G. R. Snyder. The density current regime of Franklin D. Roosevelt Lake. (In press).

Jaske, R. T. An evaluation of the use of selective discharges from Lake Roosevelt for cooling the Columbia River. BNWL 20.

173 LOW AND INTERMEDIATE LEVEL WASTE TREATMENT: Battelle-Northwest, Division of Reactor Development, U.S. Atomic Energy Commission, Richland.

The research objective is to develop processes for radionuclide removal from water and waste water so that the treated effluent can be safely and economically released to the environment.

Project Duration: Continuing.
Principal Investigator: Dr. G. J. Alkire.

Publications: Mercer, B. W. 1962. The decontamination of condensate wastes containing ammonia. U.S. Atomic Energy Commission Rept. No. HW-71627, March 1962.

Mercer, B. W. 1965. Ion exchange treatment of intermediate level wastes. U.S. Atomic Energy Commission Rept. No. BNWL-180. August 1965.

Mercer, B. W. and L. L. Ames. 1963. The adsorption of cesium, strontium, and cerium on zeolites from multication systems. U.S. Atomic Energy Commission Rept. No. HW-78461, August 1963.

Nelson, J. L., G. J. Alkire and B. W. Mercer. 1964. Inorganic ion exchange separation of cesium from Purex-type high-level radioactive wastes. Ind. & Engng. Chem. - Process Design & Dev. 3:143, April 1964.

Nelson, J. L. and B. W. Mercer. Ion exchange separation of cesium from alkaline waste supernatant solutions. U.S. Atomic Energy Commission Rept. No. HW 76449.

Skarpelos, J. M. 1963. Progress in treatment of a radioactive condensate waste. U.S. Atomic Energy Commission Rept. No. HW-79174, October 1963.

Skarpelos, J. M. 1963. Treatment of radioactive condensate waste. Procwedings of the 11th Pacific Northwest Industrial Waste Conference, Corvallis, Oregon, May 1963.

Touhill, C. J. 1965. Utilization of radioactive waste research for industrial waste treatment. Proceedings of 12th Pacific Northwest Industrial Waste Conference, Seattle, Washington, March 1965.

174 FIELD MONITORING OF RADIONUCLIDES IN SOILS AND GROUND WATER: Battelle-Northwest, Division of Production, U.S. Atomic Energy Commission, Richland.

Field investigations utilize ground water sampling and analysis, tracer techniques and specially developed monitoring equipment to define the travel and zonal distribution of low concentrations of

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radionuclides in the subsurface environment. Information so obtained is an integral part of the program for regulated disposal of low and intermediate level radioactive wastes from Hanford operations.

Principal Investigator: W. A. Haney.

Publications: Brown, D. J. and J. R. Raymond. 1962. Radiologic monitoring of ground water at the Hanford project. J. Am. Wat. Wks. Assn. 54(10):1201-1212. October 1962.

Brown, D. J., et al. Appraisal of Hanford waste disposal by integration of field techniques, pp. 181-188. Proceedings of the International Colloquium on the Retention and Migration of Radioactive Ions in Soils, Saclay (Paris).

Haney, W. A. 1964. Fission product tritium in fuel reprocessing wastes. Nucl. Saf. 5(4). October 1964.

Nelson, J. L., et al. Laboratory pilot and field scale studies of fission product migration rates in soils, pp. 107-115. Proceedings of the International Colloquium on the Retention and Migration of Radioactive Ions in Soils, Saclay (Paris).

Nelson, R. W. and A. E. Reisenauer. 1963. Application of radioactive tracers in scientific ground water hydrology. Radioisotopes in Hydrology, IAEA, Vienna, Austria, pp. 207-230, August 1963.

175 FUNDAMENTAL STUDIES ON ZEOLITE ION EXCHANGE: Battelle-Northwest, Division of Biology and Medicine, U.S. Atomic Energy Commission, Richland.

Chemical equilibria and mineralogical studies are leading to a more fundamental understanding of zeolite behavior in multication systems. The extension of this basic work to waste water treatment application is being studied.

Project Duration: Continuing.
Principal Investigator: Dr. L. L. Ames, Jr.

Publications: Ames, L. L., Jr. 1962. Effect of base cation on the cesium kinetics of clinoptilolite. Am. Miner. 47:1301-1316.

Ames, L. L., Jr. 1962. Kinetics of cesium reactions with some inorganic cation exchange materials. Am. Miner. 47:1067-1078.

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Ames, L. L., Jr. 1963. Kinetics of a replacement reaction. Econ. Geol. 58:1229-1236.

Ames, L. L., Jr. 1963. Mass action relationships of some zeolites in the region of high competing cation concentrations. Am. Miner. 48:868-882.

Ames, L. L., Jr. 1963. Synthesis of clinoptilolite-like zeolite. Am. Miner. 48:1374-1381.

Ames, L. L., Jr. 1964. Some zeolite equilibria with alkali metal cations. Am. Miner. 49:127-145.

Ames, L. L., Jr. 1964. Some zeolite equilibria with alkaline earth metal cations. Am. Miner. 49:1099-1110.

Ames, L. L., Jr. Zeolite type X equilibria with trivalent cerium and yttrium cations. J. Inorg. Nucl. Chem. 27:885-894.

176 DEVELOPMENT OF MATHEMATICAL MODELS FOR THE ANALYSIS OF LARGE COMPLEX GROUND WATER FLOW SYSTEMS: Battelle Northwest, Division of Biology and Medicine, U. S. Atomic Energy Commission and Corps of Engineers, Richland.

Digital computer programs are being developed to analyze large, heterogeneous, three-dimensional ground water flow systems, based on energy dissipation. Capacity of about 40,000 node equations is desired. Input data are potentials and physical boundaries in functional forms and permeability boundary conditions. Programs are completed for obtaining flow paths and travel times. (Immediate application is to radioactive waste transport).

Project Duration: continuing.
Principal Investigator: W. Haney.

Publications: Brown, D. J. 1963. Piezometric head distribution in sand-filled wells. Jnl. Hydrol. 1:195-203.

Nelson, R. W. 1965. A sequence for predicting waste transport by ground water. U.S. Atomic Energy Commission Rept. BNWL-63, April 15, 1965.

Oster, C. A. 1963. Genoro - a general data fitting and linear function evaluation computer code for the IBM-7090. U.S. Atomic Energy Commission Rept. HW-76692, May 1963.

177 PROCESS WATER TREATMENT OPTIMIZATION: Battelle-Northwest, Division of Production, U.S. Atomic Energy Commission, Richland.

Water treatment optimization and filtration research are being conducted to make further improvements in process water quality. The effects of physical factors, chemical factors, and irradiation factors on filtration are being examined during the research.

Project Started: 1965 (duration - continuing).
Principal Investigator: Dr. C. J. Touhill.

178 MATHEMATICAL MODEL ANALYSIS OF FLOW THROUGH PARTIALLY SATURATED HETEROGENEOUS POROUS MEDIA: Battelle-Northwest, Division of Biology and Medicine, U.S. Atomic Energy Commission, Richland.

Computer program was developed to analyze steady-state flow in unsaturated heterogeneous soils. Program uses interation techniques to solve three-dimensional cases for 8,000 grid points, using soil parameter input data for up to 13 soil types. Soil parameter measurement methods are under investigation. Extension to transient flow analysis is planned. (Immediate application is related to radioactive waste movement through the vadose zone.)

Principal Investigator: W. A. Haney.

Publications: King, L. G. 1965. Description of soil characteristics for partially-saturated flow. Proc. Soil Sci. Soc. Am.

Nelson, R. W. 1962. Steady darcian transport of fluids in heterogeneous partially-saturated porous media, Part I, Mathematical and numerical formulation. U.S. Atomic Energy Commission Rept. HW-72335, Pt. 1.

Reisenauer, A. E. 1963. Methods for solving problems of multidimensional partially-saturated steady flow in soils. J. Geophys. Res. 68(20):5725-5733.

Reisenauer, A. E., et al. 1963. Steady darcian transport of fluids in heterogeneous partially-saturated porous media, Part 2, The computer program. U.S. Atomic Energy Commission Rept. HW-72335, Pt. 2.

179 SOIL CHEMISTRY: Battelle-Northwest, Division of Biology and Medicine, U.S. Atomic Energy Commission, Richland.

A better understanding of the relationships of ion exchange and adsorption behavior for various soil types is provided by this research. The research findings are being applied to waste migration and water reclamation studies.

Project Duration: continuing.

Publications: Nelson, J. L., W. A. Haney and D. W. Bensen. 1962. Laboratory, pilot and field scale studies of fission product migration rates in soil. U.S. Atomic Energy Commission Rept. No. HW-SA-2744, September 1962.

Hajek, B. F. 1965. Some adsorption, diffusion and dispersion characteristics of anions in soils. U.S. Atomic Energy Commission Rept. BNWL-36, pp. 4.1-4.5.

Hajek, B. F. 1965. Clay mineral composition of two Hanford soils. U.S. Atomic Energy Commission Rept. No. BNWL 36-IV, pp. 4.5-4.6.

Hajek, B. F. 1965. Adsorption, migration and dispersion of strontium and cesium in an N-area soil. U.S. Atomic Energy Commission Rept. No. BNWL-CC-208.

180 MIGRATION AND DISTRIBUTION PATTERNS OF RESIDENT FISH: Battelle-Northwest for the U.S. Atomic Energy Commission, Richland.

Fish collected in the Columbia and Yakima Rivers in the area bounded by Benton City, Priest Rapids Dam and Richland are examined for Zinc-65 and Phosphorus-32 content for purposes of determining radionuclide dispersion by migrating fish.

Project Started: 1964 (duration - to July 1966).
Personnel: 1 biologist.
Principal Investigator: D. E. Watson.

Publications: Biology Department Annual Reports.

181 UPTAKE AND RETENTION OF RADIONUCLIDES BY COLUMBIA RIVER BIOTA: Battelle-Northwest, for the U.S. Atomic Energy Commission, Richland.

The purpose of this work is to investigate the cycling of radionuclides in the river biota below the Hanford reactors as this relates to concentration and dispersion of radionuclides in the ecosystem.

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Project Started: 1948 (duration - indefinite).
Personnel: 4 biologists, 2 technicians.
Principal Investigators: C. C. Coutant, C. E. Cushing, D. G. Watson, W. L. Templeton.

Publications: Annual Reports - Biology Department.

Cushing, C. E. Periphyton productivity and radionuclide accumulation in the Columbia River, Washington, U.S.A. (In press).

182 THE EFFECTS OF ENVIRONMENTAL INFLUENCES UPON UPTAKE AND TURNOVER RATES BY THE PERIPHYTON: Battelle-Northwest, for the U. S. Atomic Energy Commission, Richland.

Periphyton communities, cultured in the Columbia River and in the laboratory, are treated to a variety of environmental conditions in a specially designed exposure chamber equipped with an *in situ* radiation detector to study the effects of these conditions on the uptake and cycling of selected radionuclides. Radionuclides to be used are those found in effluent waters from the Hanford reactors. Productivity of periphyton (using C^{14} technique) will be related to radionuclide content).

Project Started: 1964 (duration - indefinite).
Personnel: 1 biologist.
Principal Investigator: C. E. Cushing.

183 REACTOR EFFLUENT MONITORING WITH FISH: Battelle-Northwest, for U.S. Atomic Energy Commission, Richland.

The purpose is to demonstrate in the laboratory effects of various concentrations of reactor effluent constituents on young fish, principally salmonids. Various industrial chemicals are tested for their toxicity to fish prior to use in reactor cooling water.

Project Started: 1945 (duration - continuing).
Personnel: 2 biologists, 1 technician.
Principal Investigators: R. E. Nakatani and P. A. Olson.

Special Equipment: fish hatchery.

Publications: Biology Department Annual Reports.

184 STUDY OF CHINOOK SALMON SPAWNING WITHIN THE ENVIRONS OF THE HANFORD RESERVATION: Battelle-Northwest, for the U.S. Atomic Energy Commission, Richland.

The purpose of this study is to determine annual fluctuations in locally spawning Chinook salmon and the relation of these fluctuations to the Hanford Works effluents and to nearby dams.

Project Started: 1947 (duration - indefinite).
Personnel: 1 biologist.
Principal Investigator: D. G. Watson.

Special Equipment: aircraft.

Publications: Biology Department Annual Reports.

185 TEMPERATURE EFFECTS ON AQUATIC ORGANISMS: Battelle-Northwest, for U.S. Atomic Energy Commission, Richland.

The purpose of this work is to determine the effects of temperature on the morphology and physiology of aquatic organisms. All levels of organization from the submicroscopic to the whole animal are being investigated.

Project Started: 1964 (duration - indefinite).
Personnel: 2 biologists, 1 technician.
Principal Investigators: J. M. Dean and R. E. Nakatani.

Special Equipment: electron microscope, respirometer.

Publications: Temperature effects on the metabolism of fish, Biology Department Annual Research Reports - 1964-1965. Battelle-Northwest.

186 COLUMNARIS DISEASE IN COLUMBIA RIVER FISHES: Battelle-Northwest, for U.S. Atomic Energy Commission, Richland.

The purpose of this study is to determine the significance of higher river temperatures and radioactive water (produced by the Hanford Works) on the endemic disease, columnaris, in salmonids. The possible aggravation of columnaris by the introduction of reactor effluent into the Columbia River is under study for the protection of the fishery resource of the river.

Project Started: 1959 (duration - indefinite).
Personnel: 1 biologist, 1 microbiologist.
Principal Investigator: M. P. Fujihara and R. E. Nakatani.

Publications: Results are reported yearly in the Biology Department's Annual Research Report.

187 DEGRADATION AND DEPLETION OF HERBICIDES IN DRAINAGE WATERS AND THEIR EFFECTS ON IRRIGATED CROPS: Battelle-Northwest, Richland.

The purpose is to identify and determine quantities of degradation products of commercial herbicides in irrigation waters and crop plants and to identify the means by which herbicidal chemicals are broken down in the environment.

Project Started: Spring 1966 (duration - 3 years).
Personnel: 1 chemist, 1 biologist, 2 technicians.
Principal Investigators: J. L. Nelson and C. C. Coutant.

Special Equipment: mass spectrometer, gas chromatograph.

188 COLUMBIA RIVER SURVEY: Crown Zellerbach Corporation, Central Research Division, Camas.

Regular water quality surveys are made in the mill area to determine the amount and distribution of mill effluents. Effects of various systems and effluent discharge are measured between Camas and Skamokawa. Mill wastes are characterized and amounts discharged are determined. Field and in-plant bioassays are run on a continuous basis. New waste treatment processes are investigated, especially in the area of automated techniques.

Other activities in the water pollution area include chemical treatment and development of useful by-products from waste products. This is being investigated extensively by the Chemical Products Division of Crown Zellerbach. Design of water and waste treatment facilities is carried out by the appropriate mill division and the central engineering office.

Project Started: 1956 (duration - continuing).
Personnel: 2 chemists, 1 microbiologist, 4 hourly workers.
Principal Investigator: Dr. H. R. Amberg.

Special Equipment: fluorometers, spectrophotometers, fermentation pilot plant, microbiological laboratory, boats for sampling.

Publications: Columbia River Study, A Progress Report 1958-1963, Crown Zellerbach Corporation, Camas Mill Division, November 1963.

189 EXPERIMENTAL STREAM PRODUCTIVITY STUDIES: Weyerhaeuser Company, Longview.

The principal objective of this project is to acquire greater knowledge of the basic principles governing biological productivity in streams, in order to evaluate with more accurate

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understanding the significance of aquatic community structural changes, particularly as such changes refer to fishes. For the purpose of these investigations, three artificial streams have been constructed on one of the company's tree farms. Water for the streams is supplied by a large spring having a fairly uniform flow of about 16 cfs.

The investigations will proceed in the following phases:

(1-a) Determine the physical and chemical characteristics of the water passing through the streams on a monthly, seasonal, and annual basis.
(1-b) Determine the aquatic community colonization rates in the test streams, and community structural changes (both qualitative and quantitative) on a monthly, seasonal, and annual basis.
(1-c) Ascertain any possible correlations between "a" and "b".
(2-a) Determine sources of energy to streams.
(2-b) Determine pathways and efficiencies of energy transfer through the major biotic levels.
(3) Introduce physical, chemical and biological variables so as to produce desired community structural changes as well as overall productivity.

Project Started: June 1965 (duration - indefinite).
Personnel: 1 engineer, 2 chemists, 2 biologists.
Principal Investigator: Rudolph Thut.

190 A STUDY OF THE PACIFIC OYSTER AND THE ESTUARINE ENVIRONMENT IN NORTH BAY OF GRAYS HARBOR: Weyerhaeuser Company, Longview.

The primary objective of the project is to attempt to determine the physical, chemical, and biological factors responsible for oyster productivity; e.g., growth, fatness, and survival. Two oyster growing areas have been selected in the North Bay of Grays Harbor, one of which produces better oysters than the other. The problem is to determine what factors or combination of factors account for the differences in oyster productivity. The plan is:

(1) To define the water masses over each area by determining the respective physical, chemical, and biological characteristics;
(2) To characterize the estuarine benthic substrate in the test areas;
(3) To determine the effects of such meteorological factors as, for example, rain, wind, solar radiation, atmospheric temperature.

The oyster undergoes a yearly physiological periodism and hence the studies are set up on a yearly basis. Special test oysters are

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maintained in each of the two test areas where they are checked for growth and mortality at monthly intervals. In addition, oysters are taken from the adjacent commercial beds in each area twice a month and analyzed for protein, glycogen, moisture, and ash. Water samples are taken from both areas once every week over a 6-8 hour period commencing at low tide. Correlation of the data is tested statistically with an IBM computer.

Project Started: January 1963 (duration - continuing).
Personnel: 1 chemist, 2 biologists, 3 laboratory technicians.
Principal Investigator: Robert B. Herrmann.

Hermann, R. B. 1963. A study of the Pacific oyster and estuarine environment in North Bay of Grays Harbor, February to June, 1963. Interim Report, Problem Plan 678.

Hermann, R. B. 1964. A study of the Pacific oyster and estuarine environment in North Bay of Grays Harbor, February to December, 1963. Interim Report, Problem Plan 678.

Herrmann, R. B. 1965. A study of the Pacific oyster and estuarine environment in North Way of Grays Harbor, January to December, 1964. Interim Report, Problem Plan 678.

191 THE ECOLOGY OF CHROMATIUM IN SEWAGE PONDS: College of Engineering Research Division, Washington State University, Pullman.

Anaerobic stabilization ponds followed by aerobic ponds have come into increasing use as a simple and cheap method of sewage treatment. Anaerobic ponds may produce unpleasant odors, but often do not. One reason for the absence of odors may be that the photosynthetic sulfur bacteria present in such ponds utilize the H_2S produced. Summer blooms of Chromatium sp. have been found in two series of waste treatment ponds in the Pullman, Washington area. Innumerable factors doubtless play a part in the growth of Chromatium and other Thiorhodaceae. Nevertheless, from the habitats in which large numbers were found, four ecological factors seem promising as ones which influence growth: sulfide content, light (abundance and quality), temperature, and dissolved oxygen content. The study aims to isolate species of Chromatium from waste treatment ponds and study the growth response of the organisms under influence of the above factors. Continuing observations will be conducted on anaerobic lagoons in an attempt to relate the ecological conditions which contribute to "blooms" of the purple sulfur bacteria.

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Project Started: October 1, 1964 (duration - 2 years).
Personnel: 1 biologist, 1 microbiologist, 2 technicians.
Principal Investigator: Donald S. May.

Special Equipment: bench-type fermentor (Microferm, manuf. by New Brunswick Instruments).

Publications: Alton, David W. 1965. Sulfide uptake by the purple sulfur bacterium Chromatium. (Special problem report for M.S. degree).

Stahl, John B. and Donald S. May. 1965. Microstratification in waste treatment ponds. Presented at the Pacific Northwest Pollution Control Association Meeting. (To be submitted to the Water Pollution Control Federation Journal).

Thompson, Ronald J. 1966. Growth of Thiopedia and Chromatium organisms on various substrates. (Special problem report for M.S. degree.)

192 ESTUARINE ECOLOGY: University of Washington, Seattle.

Description of the water quality characteristics of lower Puget Sound, Elliott Bay, Everett Bay and the Duwamish Estuary. Biological data will be collected by the Fisheries Research Institute and the Department of Oceanography, University of Washington. Various physical and chemical parameters will be measured by METRO (Municipality of Metropolitan Seattle) and the U. S. Geological Survey.

Project Objectives include:

(1) Determining population density and the dynamics of pelagic and demersal fishes in estuarine environments and how they may be affected by various waste discharge.
(2) Develop a mathematical model to simulate flushing and diffusion rates of pollutants and the movements of salmon in an estuary.
(3) To define relationships between the food supply, utilization, and growth of pelagic and demersal fishes in areas influenced by different industrial developments.

Project Started: June 1, 1965 (duration - to May 31, 1970).
Personnel: 2 biologists, 3 graduate students, 9 part-time field help, 7 fishery professors.
Principal Investigator: Dr. Donald E. Bevan.

193 EFFECT OF METAL VALENCE ON TOXICITY TO ANAEROBIC DIGESTION: University of Washington, Seattle.

A laboratory study of the effects of valence change on the toxicity of copper in anaerobic digesters.

Project Started: March 1965 (duration - 1 year).
Personnel: 2 engineers.
Principal Investigator: Dale A. Carlson.

Publications: Chmelauskas, A. J. 1965. The effect of sodium chloride and sea water on laboratory anaerobic digesters. M.S. Thesis, University of Washington.

194 PULP MILLS WASTES IN THE MARINE ENVIRONMENT: University of Washington, Seattle.

Evaluation of the changes in chemical characteristics of pulp mill wastes as a result of contact with the marine environment. Bacteria capable of degrading the lignin fraction of pulp mill wastes will be isolated, identified, and their growth characteristics defined. Whole and synthetic pulp wastes will be fractioned into two categories: a) lignin derivatives, and b) sugars and acidic sugar derivatives.

Project Started: January 1965 (duration - 2 years).
Personnel: 1 chemist.
Principal Investigator: Dale A. Carlson.

Special Equipment: total carbon analyzer.

195 UTILIZATION OF AMINO ACIDS BY ACTIVATED SLUDGE: University of Washington, Seattle.

A study of the mechanisms involved in the utilization of the major nitrogen fraction of sewage, the proteins and protein fractions. Effects of molecular size were evaluated for various protein components ranging from the simplest amino acids to the complex, difficultly degraded Keratine such as hair.

Project Started: September 1962 (duration - 3 years).
Personnel: 2 engineers.
Principal Investigator: Dale A. Carlson.

Publications: Utilization of free and combined amino acids by activated sludge. Final Report for WP 00247.

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The biological degradation of a Keratin. Symposium on Water Pollution Control, Nagpur, India. 1965.

The biological degradation of resistant proteins. Purdue Industrial Waste Conference. 1966.

196 WASTE WATER ODOR REDUCTION - MECHANISMS IN SOIL FILTERS: University of Washington, Seattle.

Disagreeable odors associated with the transportation and storage of wastes are offensive to residents in the vicinity of transportation and storage systems. The soil filter has provided an economical means of removing sewage odors. This research is concerned with establishing the responsible organisms, identifying the intermediate and storage products formed, and investigating the optimal environmental conditions for maximal degradation of malodorous compounds in soil filters. Other phases of the study will be concerned with changes in soil characteristics during gas application, with depositions that might occur such as deposition of sulfur compounds during H_2S application, with gas pressures required for various gas flow conditions and with pure culture studies of responsible bacteriat.

Project Started: September 1965 (duration - 3 years).
Personnel: 2 engineers, 1 chemist, 1 microbiologist.
Principal Investigator: Dale A. Carlson.

Equipment: GC-2 gas chromatograph.

Publications: Methyl mercaptan removal by soil filtration (Pacific Northwest International Section, APCH, November 1965).

Odor control with soil filters, the trend in engineering at the University of Washington, 1965.

197 FLUORESCENCE OF LIGNIN WASTE PRODUCTS: University of Washington, Seattle.

A systematic study of the fluorometric properties of lignin derivatives in kraft and sulfite pulping wastes. A primary objective is the development of a rapid and sensitive analytical method for the determination of the concentration and perhaps the type of pulp waste in water.

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Project Started: March 28, 1966 (duration - one year).
Personnel: 1 engineer, 1 chemist.
Principal Investigator: R. F. Christman.

Special Equipment: Model SF-1 fluorescence spectrophotometer, filtration columns, dissolved carbon analyzer, non-dispersive IR readout.

198 THE NATURE OF ORGANIC COLOR IN WATER: University of Washington, Seattle.

This research is primarily a qualitative organic study of the chemical structure of those naturally occurring molecules responsible for color in water. The color producing materials isolated by ion-exchange and solvent extraction are subjected to mild oxidation. Examination of the degradation products by thin layer chromatography and UV spectroscopy has resulted in the identification of seven structural elements of the color macromolecule.

Project Started: October 1, 1963 (duration - to March 31, 1966).
Personnel: 1 engineer, 1 chemist.
Principal Investigator: R. F. Christman.

Special Equipment: Brice-Phoenix light scattering photometer, dissolved carbon analyzer - non-dispersive IR readout.

Publications: Christman, R. F. 1964. The chemistry of color in water. The Trend in Engineering at the University of Washington 16(4):10.

Christman, R. F. and M. Ghassemi. The nature of organic color in water. Final Report to the Public Health Service. Research grant WP-00558, January 1966.

Christman, R. F. and M. Ghassemi. The chemical nature of organic color in water. J. Am. Wat. Wks. Assn. (In press).

199 LAKE WASHINGTON STUDY: University of Washington, Seattle.

Lake Washington responded to an increase over the years in the input of effluent from secondary sewage treatment plants. The productivity increased greatly as manifested by a number of changes including the increased abundance of planktonic blue-green algae. A project is underway to divert all the effluent from the lake by the middle of 1966. About half had been diverted by the middle

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of 1966. About half had been diverted by the middle of 1965, and the lake appears to be responding already. Detailed studies of the chemical and biological features of the lake will be continued as the lake continues to change. The main objective of this work is to contribute to the understanding of the role of the nutrient supply in controlling productivity and abundance of organisms in lakes.

Project Started: 1955 (duration - indefinite).
Personnel: 1 chemist, 3 biologists.
Principal Investigator: W. T. Edmondson.

Publications: Edmondson, W. T. 1965. Reproductive rate of planktonic rotifers as related to food and temperature in nature. Ecol. Monogr. 35:61-111.

Edmondson, W. T. Lake eutrophication and water quality management. (In press).

Edmondson, W. T. Changes in the oxygen deficit in Lake Washington. (In press).

Oglesby, R. T. and W. T. Edmondson. Control of eutrophication. Rehabilitation. (In press).

Also progress reports to NSF.

200 **INFLUENCE OF FOREST ECOSYSTEMS ON WATER QUALITY:** College of Forestry, University of Washington, Seattle, in cooperation with City of Seattle.

The installation of the field instrumentation necessary to evaluate water quality and the rate of water flow in the soil profile is largely completed. During the grant period of 1966 the investigation will be concerned with:

(1) Chemical analysis of leachates collected from various depths in soil profiles under untreated and treated conditions within the forest area. Inorganic and some organic constituents in the leachates will be identified.
(2) Evaluation of rate of decomposition of forest floor under field conditions by measurement of carbon dioxide production - CO_2 evaluation will be related to environmental conditions and the quality of the soil water.
(3) Movement of certain biocides through forest floor and soils.
(4) Continued study of the effect of forest removal on rate of movement of materials.

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The overall objective of this study: to relate the above features of the environment to the role of the forest ecosystem as it influences water quality.

Project Started: January 1, 1965 (duration - to January 1, 1967).
Personnel: 1 chemist, 1 biologist.
Principal Investigators: Dr. S. P. Gessel, Dr. D. W. Cole.

Special Equipment: Tension lysimeters, and various types of field recording systems related to these.

Publications: Gessel, Stanley P. and D. W. Cole. 1965. Influence of removal of forest cover on movement of water and associated elements through soil. Paper presented on July 1, 1965, at Portland, Oregon.

201 UNIQUE DETERMINATION OF LIGNIN SULFONATES IN WATER: University of Washington, Seattle.

The objective of this study is to develop a method for the determination of spent sulfite liquor in receiving waters that is unique for SSL. The approach used is to hydrolyze the lignin sulfonates in the SSL to vanillin, and to isolate and determine the vanillin.

Project Started: January 1, 1964 (duration - 3 years).
Personnel: 1 chemist.
Principal Investigator: Joseph L. McCarthy.

202 SUBLETHAL AMOUNTS OF ORGANIC INSECTICIDES AND FISH: University of Washington, College of Fisheries, Seattle.

The purpose of this study is to evaluate the effects of minute concentrations of insecticides (concentrations below the acutely toxic level) upon measurable aspects of the biology of desirable fish species. We propose to study fish subjected to insecticides from hatching until sexual maturity; in particular, to determine the effects of dilute concentrations on early embryonic growth, early development, hatching of the fish, growth, ability to swim, ability to react to stimuli, and ability to reproduce. Much of the early effort will be devoted to the development of apparatus and methodology because the methods of evaluating many of these responses have not been known. Substantial emphasis will be placed upon histological and pathological studies. In particular, studies will be made of the hematology of fish subjected to sublethal concentrations of chlorinated hydrocarbon insecticides.

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Emphasis will be placed on changes in cell morphology and changes in the numbers of cells. Biochemical tissue responses as well as tissue responses will be evaluated. It is hoped that the data will help to evaluate the effect upon aquatic life of the organic insecticides present in our waterways. This information will help regulatory agencies to set upper tolerable limits of insecticide concentrations, and to inform and educate insecticide manufacturers and users. It is hoped that it will stimulate them to adopt proper manufacturing and use patterns, and will hasten the development of specific insecticides that will not be environmental poisons.

Project Started: June 1, 1966 (duration - 5 years)
Personnel: 3 biologists.
Principal Investigator: Max Katz.

Special Equipment: Mount-Warner diluter, gas chromatograph, fish activity apparatus.

203 STUDIES OF LOW MOLECULAR WEIGHT LIGNIN SULFONATES: University of Washington, Seattle.

The objective of this study is to isolate and purify low molecular weight lignin sulfonates and determine their structure and reactivity.

Project Started: September 1, 1964 (duration - 2 years).
Personnel: 1 chemist.
Principal Investigator: Joseph L. McCarthy.

204 THE NATURE OF BLEACH PLANT EFFLUENT STREAMS: University of Washington, Seattle.

The object of this study is to determine the general nature of the substances present in the effluent liquors from pulp mill bleach plants and the relative concentrations in which the main types are present.

Project Started: January 1, 1965 (duration - 3 years).
Personnel: 1 chemist.
Principal Investigator: Joseph L. McCarthy.

205 SALT WATER ENTRAINMENT FOR DILUTION IN SEWER OUTFALLS: University of Washington, Department of Civil Engineering, Seattle.

This investigation is an experimental and analytical study of the mechanism of entrainment of a fluid of one density into a conduit passing through an infinite still volume of this ambient fluid and through which flows a fluid of different density. This particular motivation is to obtain basin information which could be applied in the sanitary engineering design of sewer outfalls discharging into salt water. Entrainment of salt water into the outfall prior to ultimate discharge would decrease the density differential between effluent and receiving water, thereby decreasing the amount of diffusion necessary to produce acceptable sewage concentrations at the water surface. Entrainment may be accomplished through inlet ports in the wall, or by an ejector configuration, placed in a reduced-pressure "venturi" section (manifold) in the outfall conduit. The investigation deals with those factors influencing entrainment rates, namely: density and pressure differentials between ambient and conduit fluids, velocity of conduit flow approaching the point of entrainment, and inlet geometry. Two basic types of configuration are being studied to obtain basic information in order to evaluate the economic feasibility and design criteria for this method of obtaining a more dilute sewer outflow.

Project Started: September 1, 1963 (duration - 3 years).
Personnel: 1 engineer, 1 graduate student, 1 machinist.
Principal Investigator: Ronald E. Nece.

Publications: Nece, R. E., P. Goldstern and J. L. Black. 1966. Single-port suction manifolds. J. Hydraul. Div. Am. Soc. Civ. Engrs., January 1966.

206 EFFECT OF DAM CONSTRUCTION ON DOWNSTREAM WATER TEMPERATURE: University of Washington, Department of Civil Engineering, Seattle.

Effects of dam construction and reservoir impoundment on one particular downstream water property-temperature are to be evaluated. Initial phases of the proposed study are aimed at obtaining a correlation between basin climatological factors and stream temperatures in the natural, pre-construction phase so that effects of construction and consequent regulation may be evaluated from comparable data obtained during and after reservoir filling stages. The field areas selected for this study are the North Fork and the Middle Fork of the Snoqualmie River, on the western slope of the Cascade Mountains in the state of Washington. Dams are proposed for each stream. The watersheds are relatively unpopulated and underdeveloped, with drainage areas of approximately 64 and 170 square miles, respectively, and are typical

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of basins in the Pacific Northwest which may be used for power, flood control, and/or recreation dams in the future. One particular application of the results of the project would be in considering the consequences of future dam projects on the ecology of downstream fish resources.

Project Started: July 1, 1965 (duration - through June 30, 1968).
Personnel: 1 engineer, 1 graduate student.
Principal Investigator: Ronald E. Nece.

207 DILUTION EFFECTS ON NUTRIENTS AND PRIMARY PRODUCTIVITY: University of Washington, Seattle.

Green Lake, Seattle, is a naturally eutrophic body of water with a high recreational use. An attempt is being made to limit primary production by continuous, large-scale addition of nutrient-poor water from the domestic supply. The primary objective of the study is to determine the rate of nutrient reduction and to demonstrate the consequent qualitative and quantitative changes in phytoplankton.

Project Started: June 15, 1965 (duration - to June 14, 1968).
Personnel: 2 biologists.
Principal Investigator: Ray T. Oglesby.

Publications: Oglesby, R. T. and W. T. Edmondson. Control of eutrophication. J. Wat. Pollut. Control. Fed. (In press).

208 EFFECTS OF A LARGE, RAW SEWAGE OUTFALL ON THE MARINE BENTHOS: University of Washington, Seattle.

Using Scuba gear, the bottom near the outfall was directly examined. A sampling program was evolved, which included a spectrum of bottom conditions ranging from clean sand to organic sludge. Plastic tubing was permanently mounted at the mud-water interface and extended buoys at the surface so that water samples could be drawn from just off the bottom for each station. Net bottom currents were determined by taking measurements at short intervals of time over a 40 hour period. Chemical studies were made of the following parameters: DO, ammonia, H_2S, Pb, Cu, organic and inorganic solids. Extensive bottom surveys are being made for study of the benthic fauna. Correlations are being sought between carefully-defined marine environments exhibiting various degrees of organic pollution and the kinds and numbers of organisms which inhabit them.

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Project Started: January 1965 (duration - to August 1966).
Personnel: 2 biologists.
Principal Investigator: R. T. Oglesby.

209 STUDY OF SALMON STOCKS OF THE SNOHOMISH RIVER WATERSHED: University of Washington, Seattle.

Study of the physical and some chemical characteristics of the Snohomish River watershed in relation to the ecology of Chinook and coho salmon. The study is an auxiliary or addition to the study of the water quality of Everett Bay and its role as an area of salmon migration and residence.

Project Started: September 1965 (duration - to September 1966).
Personnel: 5 biologists.
Principal Investigator: Ernest O. Salo.

210 EFFECTS OF LOGGING ON THE PRODUCTIVITY OF PINK SALMON STREAMS IN ALASKA: Fisheries Research Institute, University of Washington, Seattle.

The U. S. Forest Service initiated studies to evaluate the effects of logging on the productivity of salmon streams in Southeastern Alaska at Hollis in 1949. In 1956, the Fisheries Research Institute commenced a study of the biological aspects of the effects of logging. The physical and biological characteristics of four streams in the Hollis area have been monitored since 1956. The study has two major objectives:

(1) To determine the effects of logging on the quality of the spawning bed and stream environment as it pertains to growth, development, and survival of salmon eggs and alevins.
(2) To provide criteria for increasing the production of fry, the improvement of natural spawning areas, and the construction of artificial spawning areas.

Project Started: 1956 (duration - indefinite).
Personnel: 3 biologists.
Principal Investigator: Ernest O. Salo

Publications: McNeil, William J. 1964. A method of measuring mortality of pink salmon eggs and larvae. U. S. Fish and Wildlife Service, Fishery Bulletin 63(3):575-588. University of Washington, College of Fisheries, Contribution No. 119.

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McNeil, William J. 1964. Redd superimposition and egg capacity of pink salmon spawning beds. J. Fish. Res. Bd. Can. 21(6):1385-1386. University of Washington, College of Fisheries, Contribution No. 197.

McNeil, William J. and Warren H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed material. U. S. Fish and Wildlife Service Special Scientific Report - Fisheries No. 469. University of Washington, College of Fisheries, Contribution No. 197.

Shapley, S. Philip and Daniel M. Bishop. 1965. Sedimentation in a salmon stream. J. Fish. Res. Bd. Can. 22(4):919-928. University of Washington, College of Fisheries, Contribution No. 76.

Sheridan, William L. 1960. Frequency of digging movements of female pink salmon before and after egg deposition. An. Behav. 8(3-4):228-230, July-October. University of Washington, College of Fisheries, Contribution No. 68.

Sheridan, William L. 1961. Temperature relationships in a pink salmon stream in Alaska. Ecology 42(1):91-98, January. University of Washington, College of Fisheries, Contribution No. 76.

211 STUDY OF THE EFFECT OF REFUSE DISPOSAL ON THE WATER QUALITY OF UNION BAY: University of Washington, Seattle.

Since about 1930 the city of Seattle has used the marshland in and around Union Bay for the disposal of waste materials (garbage, refuse, ashes, etc.). This arrangement has been mutually beneficial to the city of Seattle and the University of Washington, for considerable land has been reclaimed at a nominal cost to the University. Union Bay is a small, shallow body of fresh water which forms the outlet of Lake Washington into Lake Union which drains eventually into Puget Sound. The purpose of the study is to collect and evaluate water quality data in and around the edge of Union Bay to determine the effect, if any, the refuse disposal operation has or will have on the water quality of Union Bay. The major emphasis is on the possible eutrophication of the adjacent waters.

Project Started: July 1, 1961 (duration - to July 1, 1966).
Personnel: 1 engineer.
Principal Investigator: Robert W. Seabloom.

212 AN INTEGRATED STUDY OF THE WATER RESOURCES OF WASHINGTON - WATER QUALITY: University of Washington, Department of Civil Engineering, Seattle.

Evaluation of present and predicted future (under various alternative development possibilities) water quality in the state of Washington.

Project Started: November 1965 (duration - to November 1966).
Personnel: 2 engineers.
Principal Investigator: Robert O. Sylvester.

213 A STUDY OF THE WATER ENVIRONMENT IN SOUTHEAST GEORGIA STRAIT IN ASSOCIATION WITH THE INTALCO ALUMINUM PLANT: University of Washington, Civil Engineering Department, Seattle.

To determine possible impact of a new aluminum reduction plant on the marine environment.

(1) Study of water mass movement.
(2) Effluent characteristics and their behavior in sea water.
(3) Effluent constituents present in sea water.
(4) Calculation of effluent dispersion from submarine outfall.
(5) To determine most desirable location for outfall.
(6) Document existing flora and fauna of area (intertidal).
(7) Determine bottom current velocities.
(8) Document benthic flora and fauna.
(9) Document existing fishery resources.
(10) Existing marine water quality seasonally.
(11) Bioassay studies with effluent.
(12) Evaluation of above data.

Project Started: June 16, 1965 (duration - to December 31, 1966).
Personnel: 2 engineers, 1 chemist, 3 biologists.
Principal Investigator: Robert O. Sylvester.

WYOMING

214 EVAPO-TRANSPIRATION AND IRRIGATION EFFICIENCY STUDIES: University of Wyoming, Laramie.

To measure growing season evapo-transpiration and make correlations with climatic factors. To determine border, field and farm efficiency of water use. To estimate probable future farm irrigation water needs.

Project Started: August 1961 (duration - 6 years).
Personnel: 2 engineers, 1 soil technician.
Principal Investigator: Robert Burman.

Special Equipment: humidity and temperature gradient sensing and recording equipment; neutron moisture probes, net sensors and recorders for measuring vertical energy balances (net radiation, solar radiation, albedo, soil heat flow); wind speed and direction recording equipment.

215 MICROCLIMATIC FACTORS FOR FOUR PLANT COMMUNITIES ON ELK MOUNTAIN: University of Wyoming, Laramie.

To study the effect of two methods of sagebrush control on the following:

(1) Moisture retention and depletion in the soil.
(2) The total energy balance over the plant canopy.
(3) Stands and production of native forage and the weedy species.

To describe and map various plant communities at four elevations on the Northwest exposure of Elk Mountain and to relate them to certain hydrologic parameters within these plant communities.

Project Started: July 1965 (duration - 5 years).
Personnel: 2 engineers.
Principal Investigator: Clarence Becker.

Special Equipment: humidity and temperature gradient sensing and recording equipment; neutron moisture probes; net sensors and recorders for measuring vertical energy balances (net radiation, solar radiation, albedo, soil heat flow); wind speed and direction recording equipment.

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